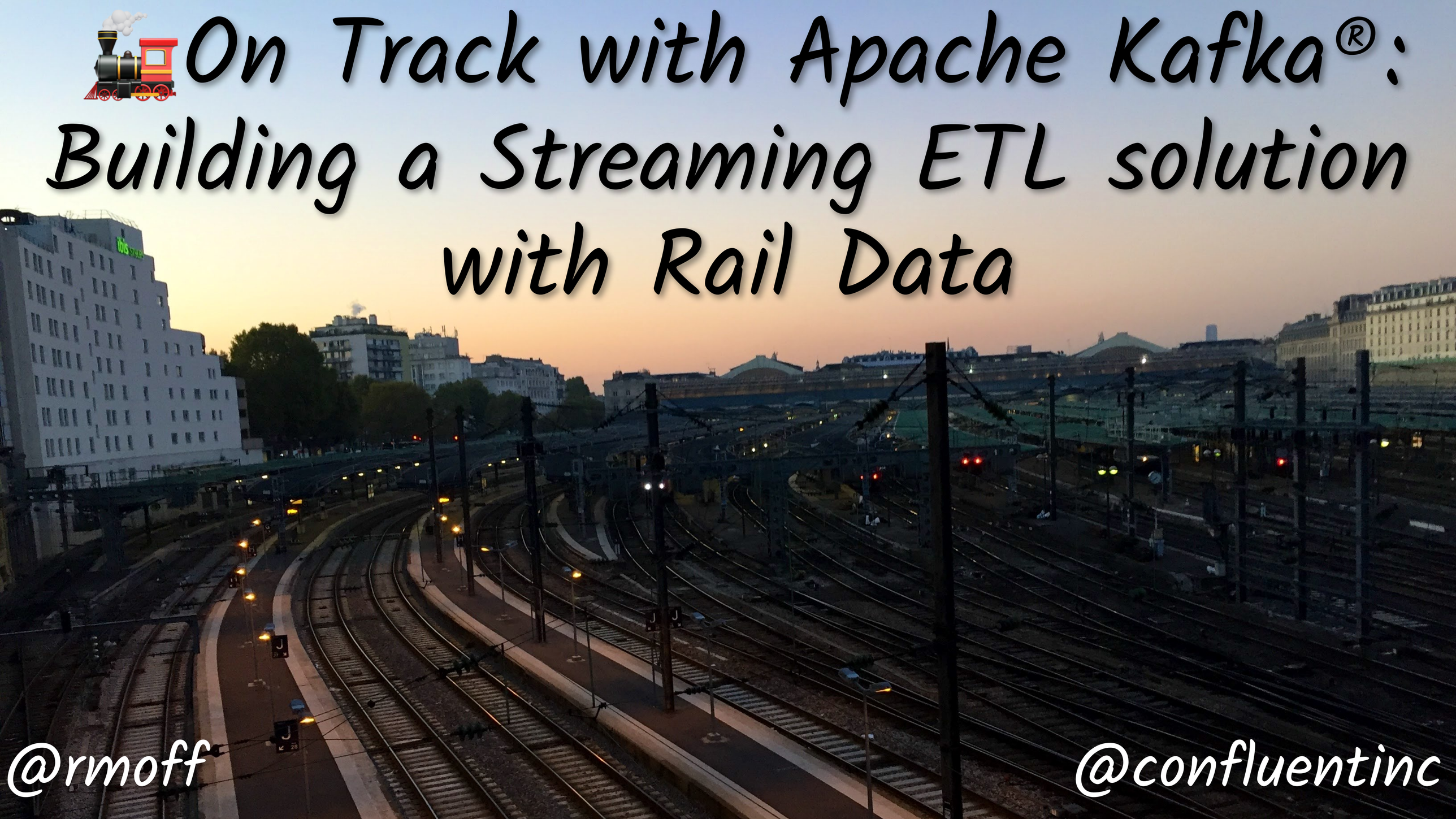
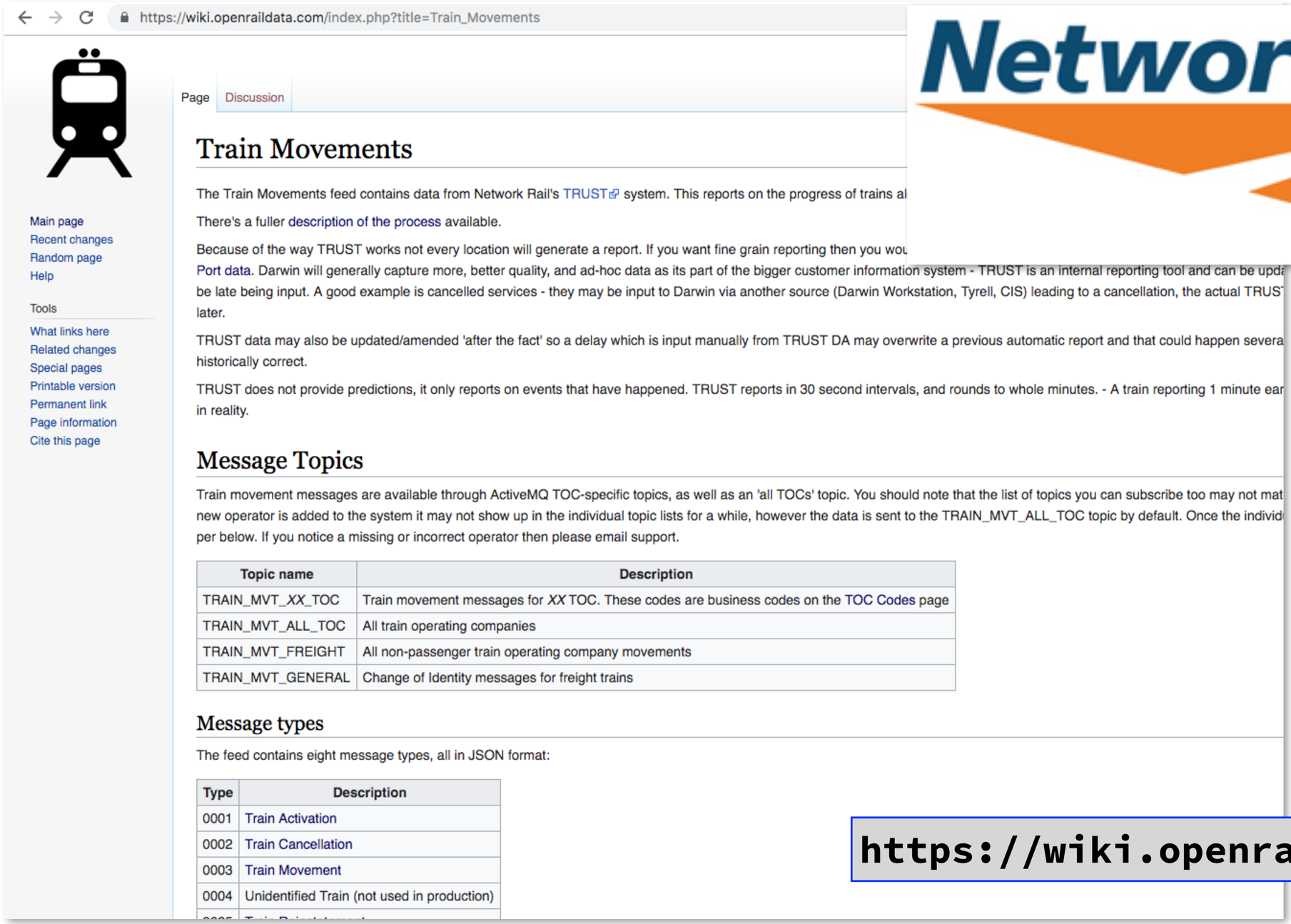

On Track with Apache Kafka®:
Building a Streaming ETL solution
with Rail Data
@rmoff
@confluentinc

KAFKA
STREAMS
WITH (KAFKA_TOPIC='CIF_
VALUE_FORMAT='JSO
confluent

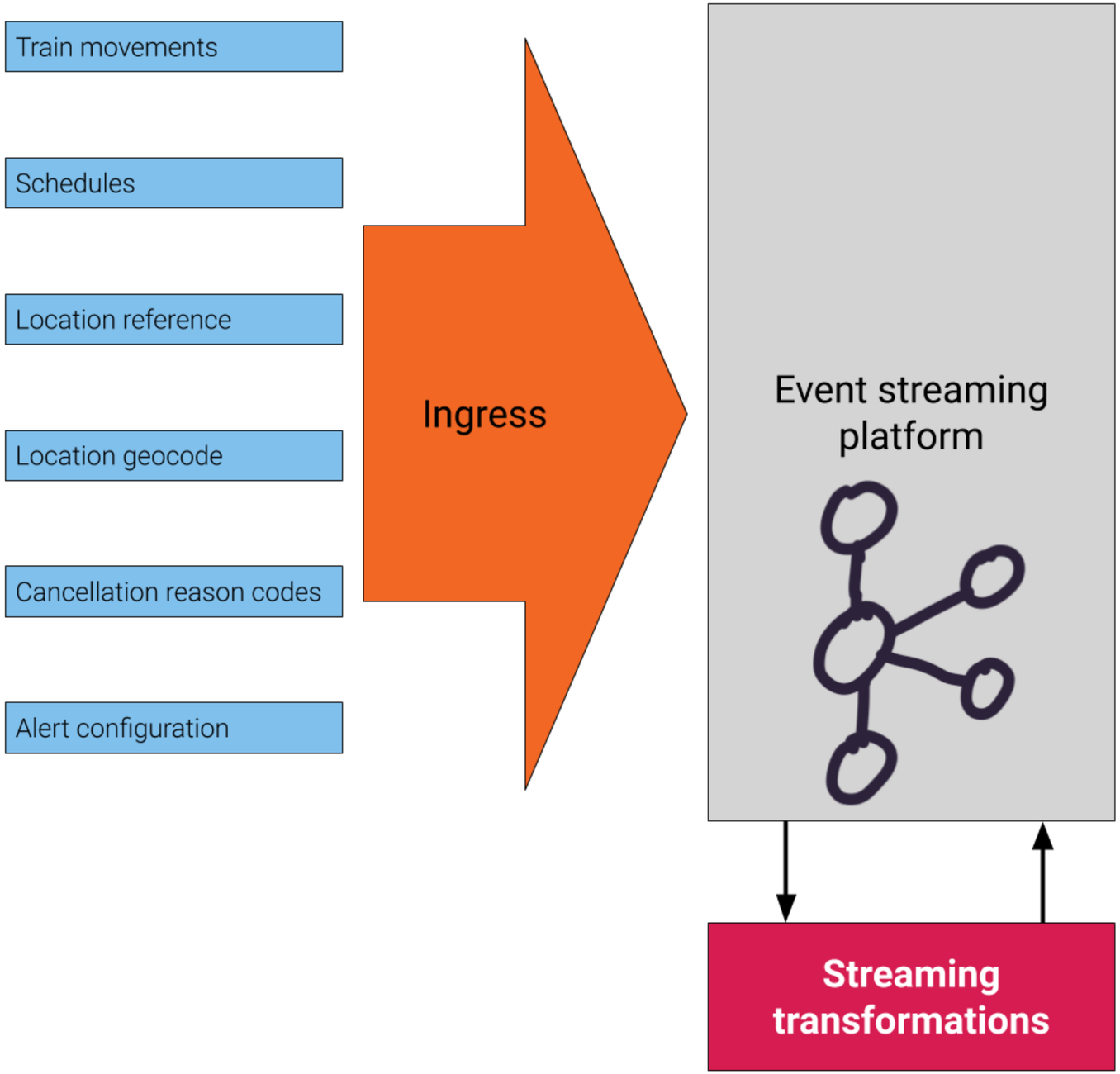
h/t @kennybastani / @gamussa

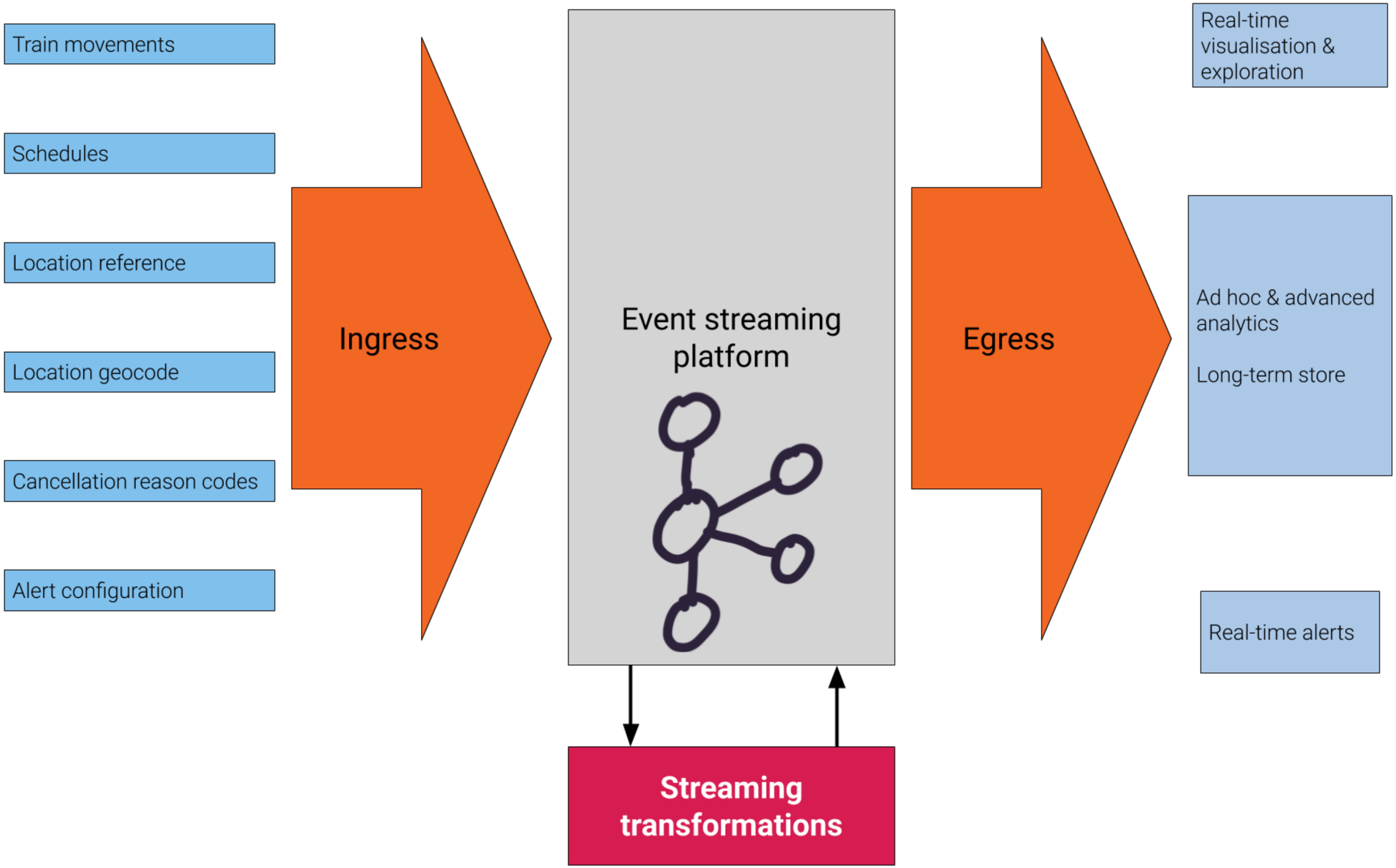
Departures 1
Due Destination Plat Expected
11:48 Sheffield via 11A On time
11:50 Manchester Air 16A On time
11:51 Blackpool Nth 11C On time
11:52 Newcastle 15A On time
11:53 Huddersfield via 13B On time
11:55 Selby 7A On time
11:56 Skipton 1B On time
11:58 Knottingley via 12D 12:08
11:59 Knaresborough via 5C On time
12:03 Ilkley 2B On time
12:06 Liverpool L St via 16A On time
12:06 Brighouse via 8B On time
12:08 Glasgow Cent. 9D On time
Delayed due to
signalling problems
12:09 Nottingham 17B On time
12:11 Middlesbrough 15B On time
12:11 Plymouth 11A 12:16
Departures 2
11:48
Due Destination Plat Expected
12:12 Bradford F Sq 1B 12:19
12:15 Harrogate 4B On time
12:15 London Kings X On time
Platform to be confirmed
please wait on the concourse
12:18 Manchester Air 16A On time
12:18 Morecambe 3B On time
12:18 via Halifax 10B On time
12:20 via Dewsbury 13B On time
12:21 Scarborough 15B On time
12:21 Doncaster On time
12:24 York 7A On time
12:26 Skipton 5C On time
12:28 Knottingley 12A On time
via Wakefield Westgate
12:29 via Harrogate 4B On time
12:30 via Castleford 17A On time
12:33 Ilkley 2B On time
Special Notices
Due to congestion near
the ticket gates: please
wait on the concourse
until the platform
displays for London KX
services. Thank you.
Welcome to
Leeds
Station
Arrivals
Newcastle
London Kings X
Liverpool L St
Plymouth
Manchester Air
Glasgow Cent.
London Kings X
Liverpool L St
Newcastle
Manchester Air
Blackpool Nth
Hull



NetworkRail

https://wiki.openraildata.com


Train movements
Schedules
Location reference
Location geocode
Cancellation reason codes
Alert configuration
Ingress
Event streaming platform
Streaming transformations


Train movements
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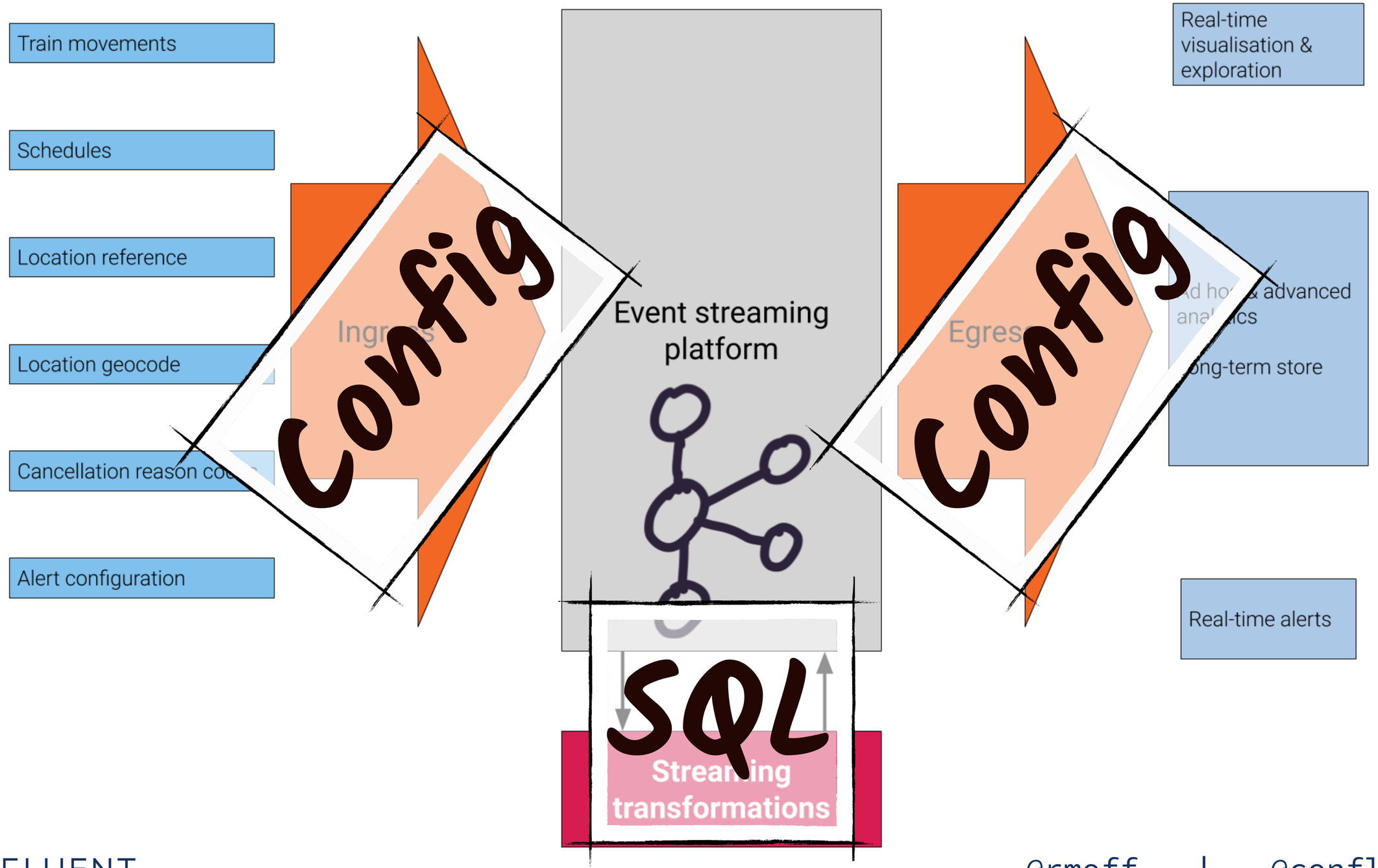
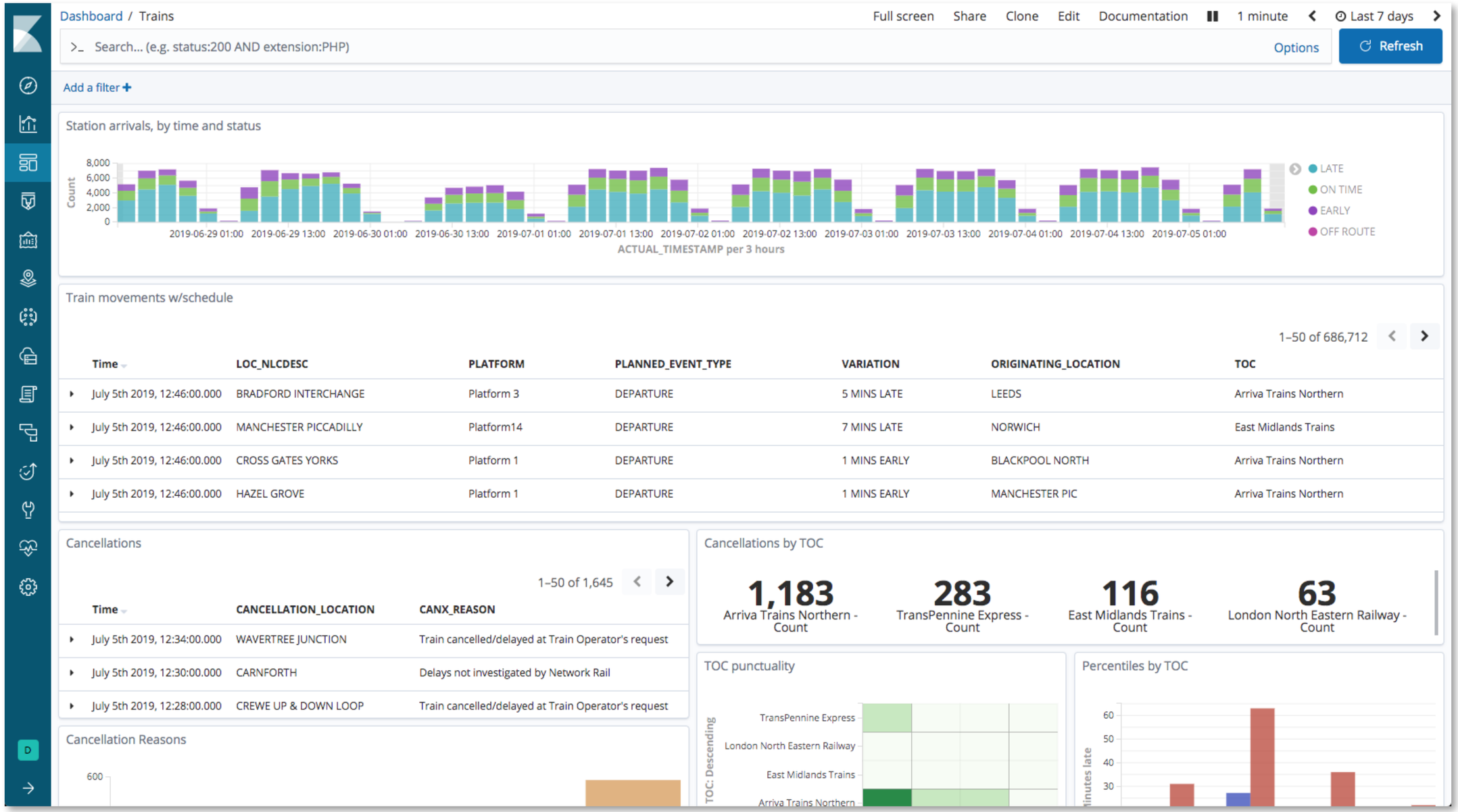
Event streaming platform
Egress
Real-time visualisation & exploration
Ad hoc & advanced analytics
Long-term store
Real-time alerts
Streaming transformations


Train movements
Schedules
Location reference
Location geocode
Cancellation reason co
Alert configuration
Config
Ingress
Event streaming platform
SQL
Streaming transformations
Egress
Config
Real-time visualisation & exploration
advanced
ng-term store
Real-time alerts

Real-time visualisation of rail data



Real-time visualisation of rail data

Code!

confluentinc / demo-scene

Unwatch 48 | Star 148 | Fork 85

Code | Issues 4 | Pull requests 0 | Security | Insights | Settings

Branch: master ▾ demo-scene / rail-data-streaming-pipeline / Create new file | Upload files | Find file | History

rmoff Increase Consumer poll interval (telegram sink was failing to commit ... Latest commit a9ef3b9 12 minutes ago

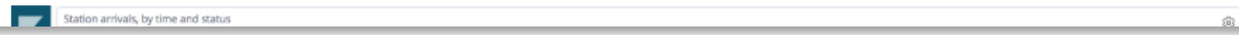
..		
data	Increase batch size	17 minutes ago
images	Update README	23 hours ago
.gitignore	Update gitignore	17 days ago
00_replicator_source.sh	Add to topic list	17 days ago
README.adoc	Update README	23 hours ago
docker-compose.yml	Increase Consumer poll interval (telegram sink was failing to commit ...	12 minutes ago
friction_log.adoc	Update friction log	23 days ago
national rail.json	First commit of rail stuff	2 months ago
network_rail_notes.txt	First commit of rail stuff	2 months ago

README.adoc

Building a Streaming Data Pipeline with Rail Data

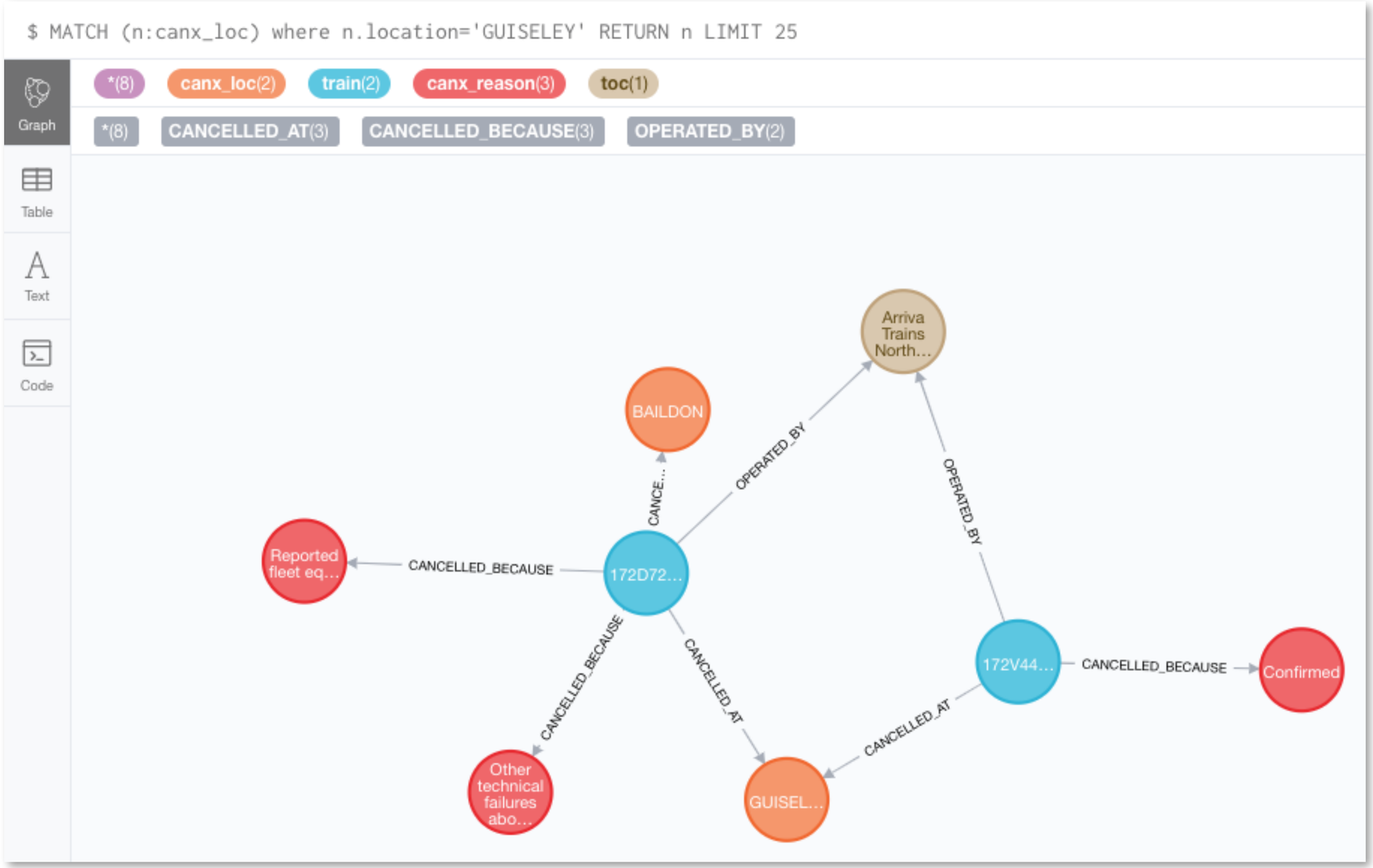
What is it?

A PoC showing what can be done with streaming and batch sources of data, Apache Kafka and KSQL, and various data stores and tools.

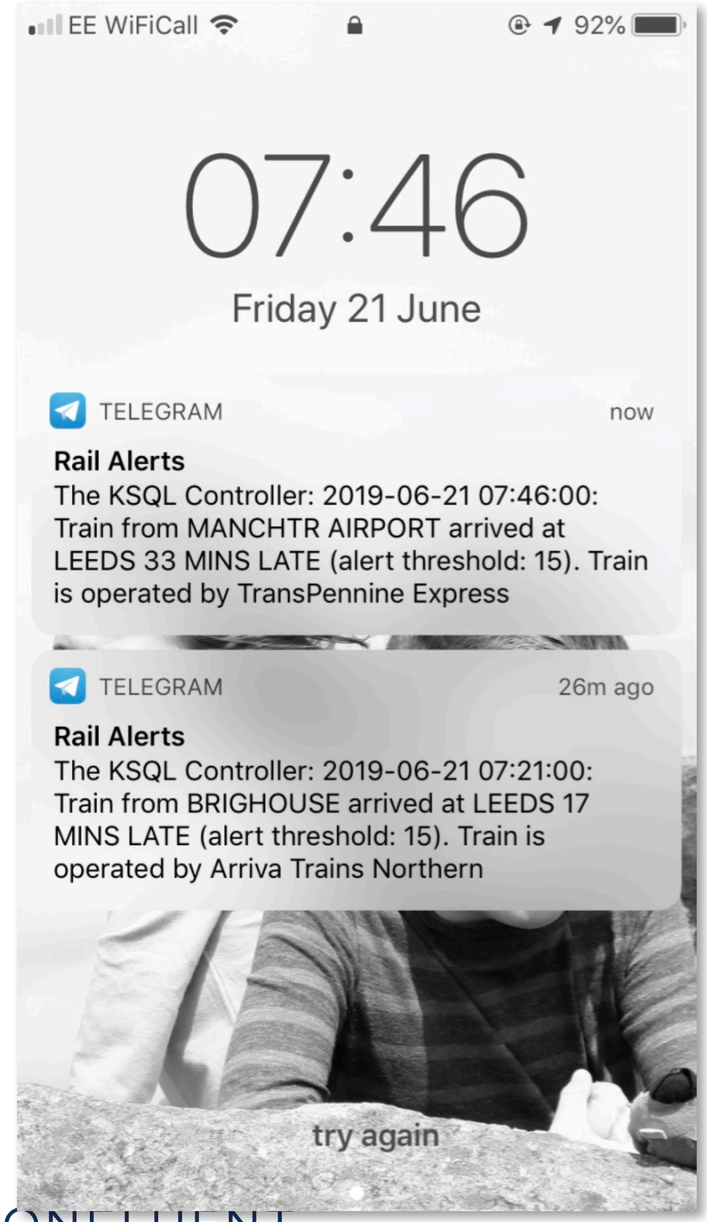


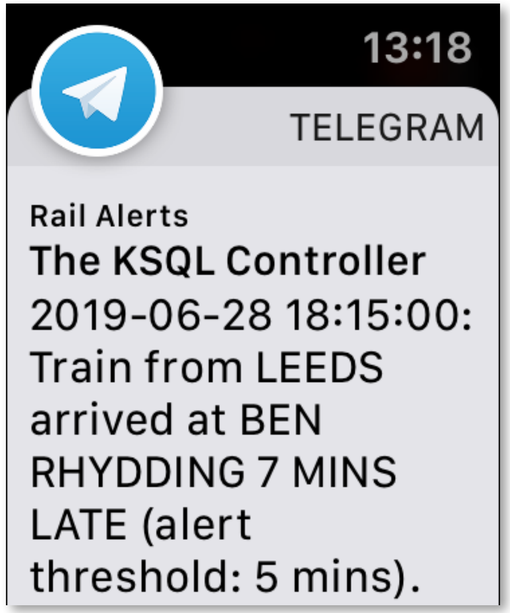
http://rmoff.dev/kafka-trains-code-01

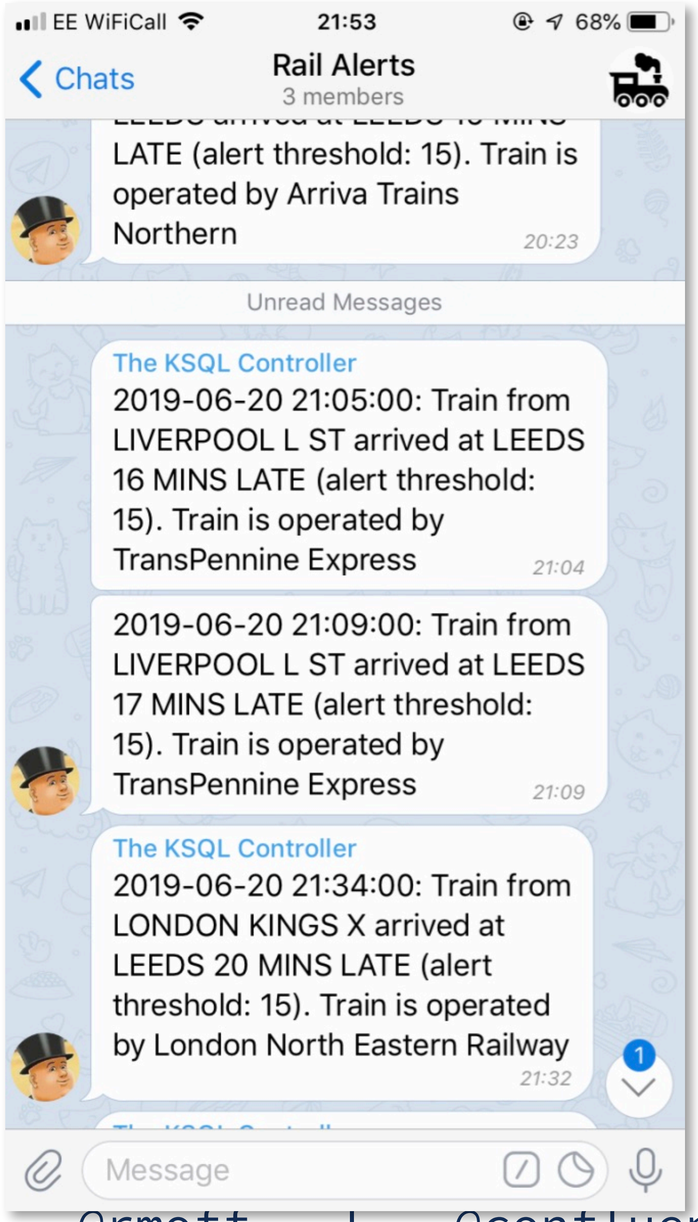
Graph relationships



Realtime Alerts







Getting the data in

Data Sources

Train Movements

Continuous feed

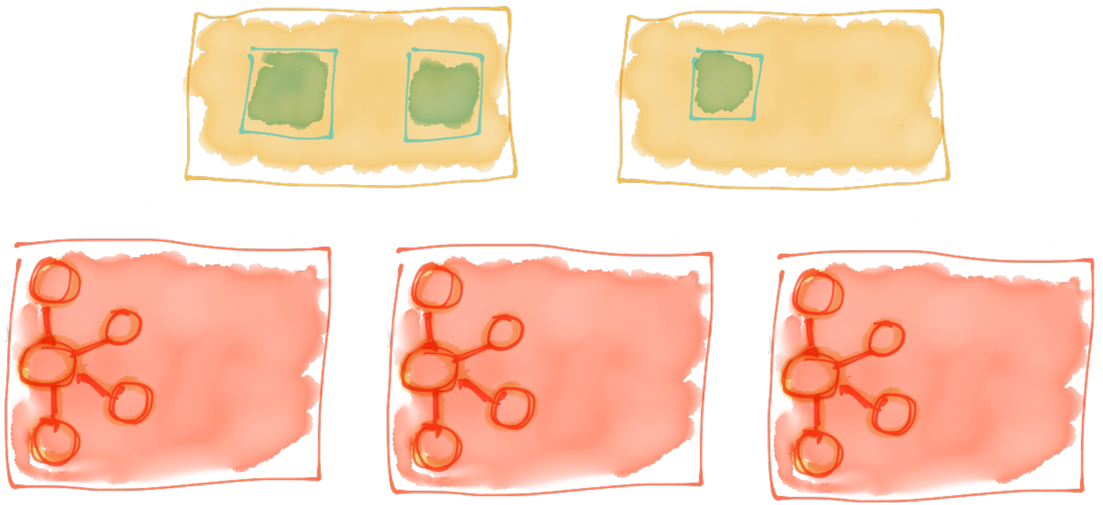
Schedules

Updated Daily

Reference data

Static

Streaming Integration with Kafka Connect



Kafka Connect

Kafka Brokers

kafkacat

- Kafka CLI producer & consumer
  - Also metadata inspection
- Integrates beautifully with unix pipes!

```
curl -s “https://my.api.endpoint" | \
kafkacat -b localhost:9092 -t topic -P
```

- Get it!
  - https://github.com/edenhill/kafkacat/
  - apt-get install kafkacat
  - brew install kafkacat
  - https://hub.docker.com/r/confluentinc/cp-kafkacat/

https://wiki.openraildata.com/index.php?title=Train_Movements

Apache ACTIVEMQ

Movement data

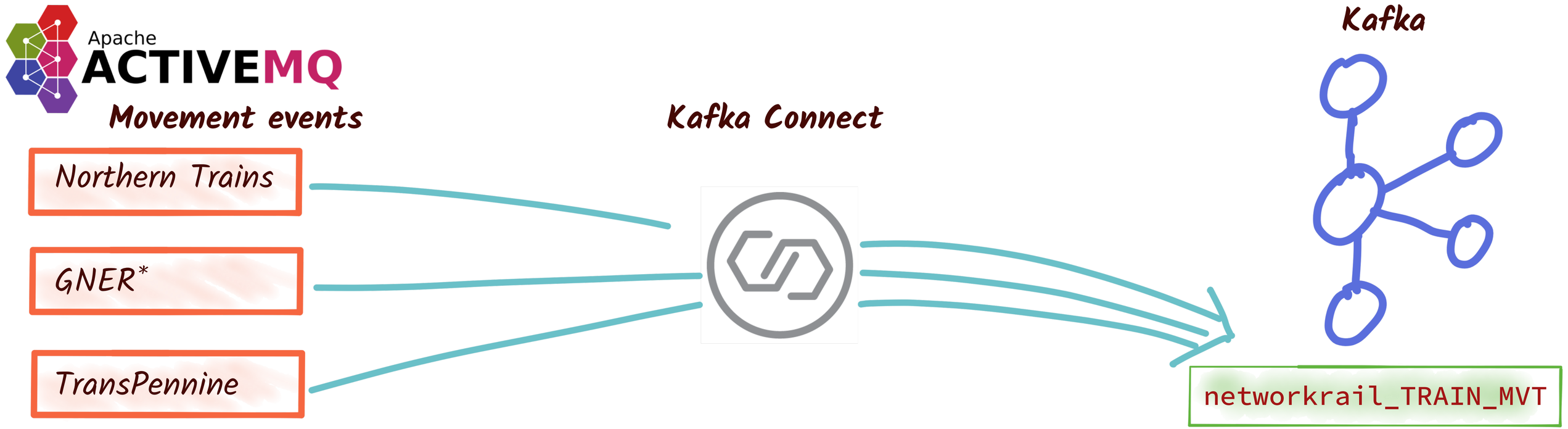
A train's movements
- Arrived / departed
- Where
- What time
- Variation from timetable

A train was cancelled
- Where
- When
- Why

A train was 'activated'
- Links a train to a schedule

Ingest ActiveMQ with Kafka Connect

```
"connector.class"      : "io.confluent.connect.activemq.ActiveMQSourceConnector",
"activemq.url"         : "tcp://datafeeds.networkrail.co.uk:61619",
"jms.destination.type": "topic",
"jms.destination.name": "TRAIN_MVT_EA_TOC",
"kafka.topic"          : "networkrail_TRAIN_MVT",
```



* Remember them?

```
{
    "messageID": "ID:opendata-backend.rockshore.net-44604-1564338858341-11:518:2:35:43470",
    "messageType": "text",
    "timestamp": 1565864716708,
    "deliveryMode": 2,
    "correlationID": null,
    "replyTo": null,
    "destination": {
        "destinationType": "topic",
        "name": "TRAIN_MVT_EM_TOC"
    },
    "redelivered": false,
    "type": null,
    "expiration": 1565865016708,
    "priority": 4,
    "properties": {},
    "bytes": null,
    "map": null,
    "text": "[{\"header\":{\"msg_type\":\"0003\",\"source_dev_id\":\"\",\"user_id\":\"\",\"ori
":\"TRUST\"},\"body\":{\"event_type\":\"DEPARTURE\",\"gbtt_timestamp\":\"\",\"original_loc_sta
_loc_timestamp\":\"\",\"current_train_id\":\"\",\"delay_monitoring_point\":\"false\",\"next_re
,\"correction_ind\":\"false\",\"event_source\":\"AUTOMATIC\",\"train_file_address\":null,\"pla
F15\",\"offroute_ind\":\"false\",\"variation_status\":\"ON TIME\",\"train_service_code\":\"221
nd\":\"DOWN\",\"route\":\"2\",\"planned_event_type\":\"DEPARTURE\",\"next_report_stanox\":\"27
_id\":\"\",\"original_data_source\":\"SMART\",\"msg_queue_timestamp\":\"1565864707000\",\"sour
original_loc_stanox\":\"\",\"planned_timestamp\":\"1565868150000\",\"timetable_variation\":\"3
rue\",\"next_report_run_time\":\"2\",\"reporting_stanox\":\"62400\",\"actual_timestamp\":\"156
ss\":null,\"platform\":\" 5\",\"division_code\":\"28\",\"train_terminated\":\"false\",\"train_
e_code\":\"22150000\",\"toc_id\":\"28\",\"loc_stanox\":\"62400\",\"auto_expected\":\"true\",\"
_stanox\":\"62209\",\"line_ind\":\"F\"}},{\"header\":{\"msg_type\":\"0003\",\"source_dev_id\":
07000\",\"source_system_id\":\"TRUST\"},\"body\":{\"event_type\":\"DEPARTURE\",\"gbtt_timestam
ariation\":\"0\",\"original_loc_timestamp\":\"\",\"current_train_id\":\"\",\"delay_monitoring_
estamp\":\"1565868300000\",\"correction_ind\":\"false\",\"event_source\":\"AUTOMATIC\",\"train
e\",\"train_id\":\"572N31MH15\",\"offroute_ind\":\"false\",\"variation_status\":\"ON TIME\",\"
d\":\"true\",\"direction_ind\":\"DOWN\",\"route\":\"1\",\"planned_event_type\":\"DEPARTURE\",\
ource_dev_id\":\"\",\"user_id\":\"\",\"original_data_source\":\"SMART\",\"msg_queue_timestamp\
gbtt_timestamp\":\"\",\"original_loc_stanox\":\"\",\"planned_timestamp\":\"1565868150000\",\"t
```


Envelope

Payload

Message transformation

```
kafkacat -b localhost:9092 -G tm_explode
  networkrail_TRAIN_MVT -u | \
 jq -c '.text|fromjson[]' | \
 kafkacat -b localhost:9092 -t
  networkrail_TRAIN_MVT_X -T -P
```


```
{
    "header": {
        "msg_type": "0003",
        "source_dev_id": "",
        "user_id": "",
        "original_data_source": "SMART",
        "msg_queue_timestamp": "1558694355000",
        "source_system_id": "TRUST"
    },
    "body": {
        "event_type": "DEPARTURE",
        "gbtt_timestamp": "",
        "original_loc_stanox": "",
        "planned_timestamp": "1558697700000",
        "timetable_variation": "4",
        "original_loc_timestamp": "",
        "current_train_id": "",
        "delay_monitoring_point": "false",
        "next_report_run_time": "4",
        "reporting_stanox": "00000",
        "actual_timestamp": "1558697940000",
        "correction_ind": "false",
        "event_source": "AUTOMATIC"
```

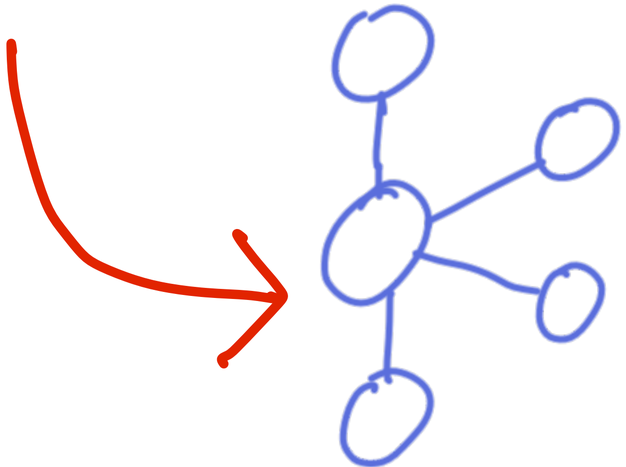
https://wiki.openraildata.com/index.php?title=SCHEDULE

Schedule data

Train routes
Type of train (diesel/electric)
Classes, sleeping accomodation, reservations, etc

Load JSON from S3 into Kafka

```
curl -s -L -u "$USER:$PW" "$FEED_URL" | \
  gunzip | \
  kafkacat -b localhost -P -t CIF_FULL_DAILY
```



https://wiki.openraildata.com/index.php?title=SCHEDULE

Reference data

- Train company names
- Location codes
- Train type codes
- Location geocodes

Geocoding

Type of geocoding Forward Reverse

Address or place name ILKLEY

API Key YOUR-API-KEY

Geocode

Results for "ILKLEY"

Results Map

Summary (see ful

1. Ilkley
   53.9257254
2. Ilkley,
   53.9247929

Results Map Request URL JSON Response

```
https://api.opencagedata.com/geocode/v1/json?q=ILKLEY&key=YOUR-API-KEY&language=en&pretty=1
```

Results Map Request URL JSON Response

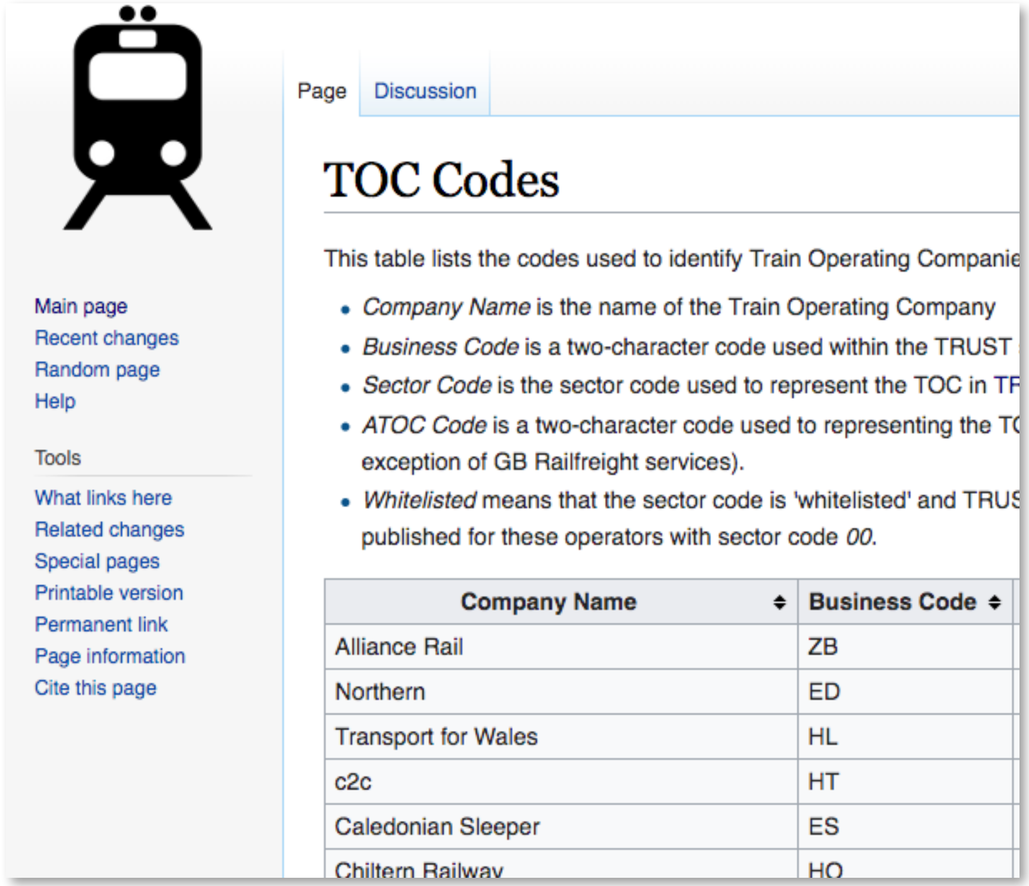

```
HTTP Status code: 200

HTTP Headers:
  Content-Type: application/json; charset=utf-8
  Access-control-allow-origin: *
  X-RateLimit-Limit: 15000
  X-RateLimit-Remaining: 14934
  X-RateLimit-Reset: 1568246400

Content:

{
  "documentation": "https://opencagedata.com/api",
  "licenses": [
    {
      "name": "see attribution guide",
      "url": "https://opencagedata.com/credits"
    }
  ],
  "rate": {
    "limit": 15000,
    "remaining": 14934,
    "reset": 1568246400
  },
  "results": [
    {
      "annotations": {
        "DMS": {
          "lat": "53° 55' 32.61144'' N",
          "lng": "1° 49' 27.98760'' W"
        }
```

Static reference data



Page Discussion

TOC Codes

This table lists the codes used to identify Train Operating Companie

- *Company Name* is the name of the Train Operating Company
- *Business Code* is a two-character code used within the TRUST
- *Sector Code* is the sector code used to represent the TOC in TF
- *ATOC Code* is a two-character code used to representing the TC exception of GB Railfreight services).
- *Whitelisted* means that the sector code is 'whitelisted' and TRUS published for these operators with sector code *00*.

Main page
Recent changes
Random page
Help

Tools

What links here
Related changes
Special pages
Printable version
Permanent link
Page information
Cite this page

Company Name	Business Code
Alliance Rail	ZB
Northern	ED
Transport for Wales	HL
c2c	HT
Caledonian Sleeper	ES
Chiltern Railway	HO

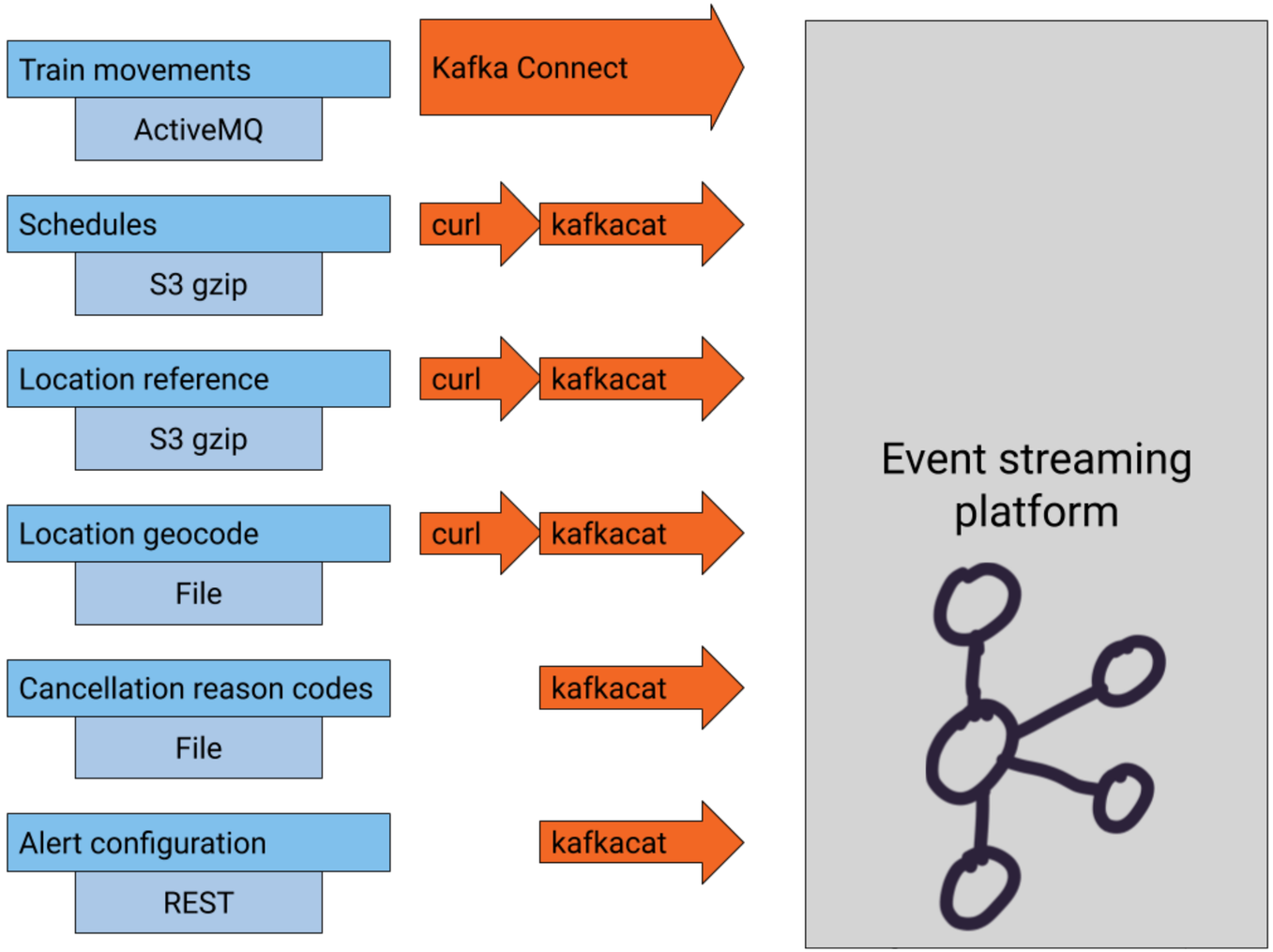
Code	Cause	Abbreviation
AA	Waiting acceptance into off Network Terminal or Yard	ACCEPTANCE
AC	Waiting train preparation or completion of TOPS list/RT3973	TRAIN PREP
AD	Off Network Terminal or Yard staff shortage including reactionary congestion caused by the shortage	WTG STAFF
AE	Congestion in off Network Terminal or Yard	CONGESTION
AG	Wagon load incident including adjusting loads or open door	LOAD INCDT
AH	Customer or off Network yard equipment breakdown/reduced capacity	YARD EQUIP
AJ	Waiting Customer's traffic including documentation	TRAFFIC
AK	Safety incidents and mishaps (e.g. derailments, fire or chemical spill) in off Network Rail network freight yard or terminal (including private sidings, and stations – where it affects FOC services)	YARDSAFETY
AX	Failure of off network infrastructure (FOC or private)	OFFNET INF
AZ	Other Freight Operating Company. Cause to be specified, including mishaps in off Network terminals or yards	YARD OTHER
DA	Non Technical Fleet Holding Code	HOLD NT FL
DB	Train Operations Holding Code	HOLD T-OPS
DC	Train Crew Causes Holding Code	HOLD T-CRW
DD	Technical Fleet Holding Code	HOLD T FL
DE	Station Causes Holding Code	HOLD STN
DF	External Causes Holding Code	HOLD EXT

```
AA:{"canx_reason_code":"AA","canx_reason":"Waiting acceptance into off Network Terminal or Yard"}
AC:{"canx_reason_code":"AC","canx_reason":"Waiting train preparation or completion of TOPS list/RT3973"}
AE:{"canx_reason_code":"AE","canx_reason":"Congestion in off Network Terminal or Yard"}
AG:{"canx_reason_code":"AG","canx_reason":"Wagon load incident including adjusting loads or open door"}
AJ:{"canx_reason_code":"AJ","canx_reason":"Waiting Customer's traffic including documentation"}
DA:{"canx_reason_code":"DA","canx_reason":"Non Technical Fleet Holding Code"}
DB:{"canx_reason_code":"DB","canx_reason":"Train Operations Holding Code"}
DC:{"canx_reason_code":"DC","canx_reason":"Train Crew Causes Holding Code"}
DD:{"canx_reason_code":"DD","canx_reason":"Technical Fleet Holding Code"}
DE:{"canx_reason_code":"DE","canx_reason":"Station Causes Holding Code"}
DF:{"canx_reason_code":"DF","canx_reason":"External Causes Holding Code"}
DG:{"canx_reason_code":"DG","canx_reason":"Freight Terminal and or Yard Holding Code"}
DH:{"canx_reason_code":"DH","canx_reason":"Adhesion and or Autumn Holding Code"}
FA:{"canx_reason_code":"FA","canx_reason":"Dangerous goods incident"}
FC:{"canx_reason_code":"FC","canx_reason":"Freight train driver"}
```

Flat file

```
kafkacat -l canx_reason_code.dat
    -b localhost:9092 -t canx_reason_code -P -K:
```

Kafka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curl
kafkacat
Cancellation reason codes
File
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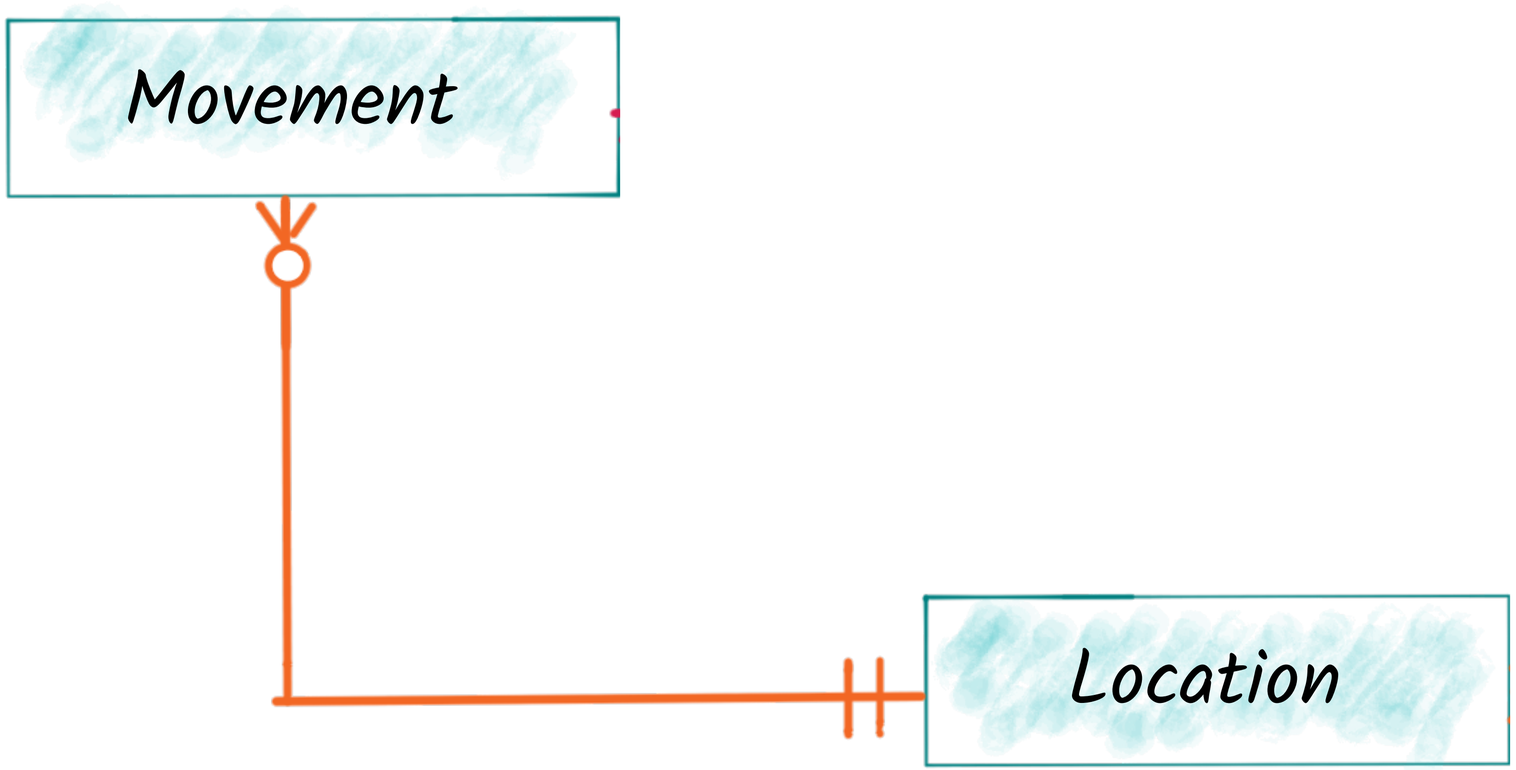
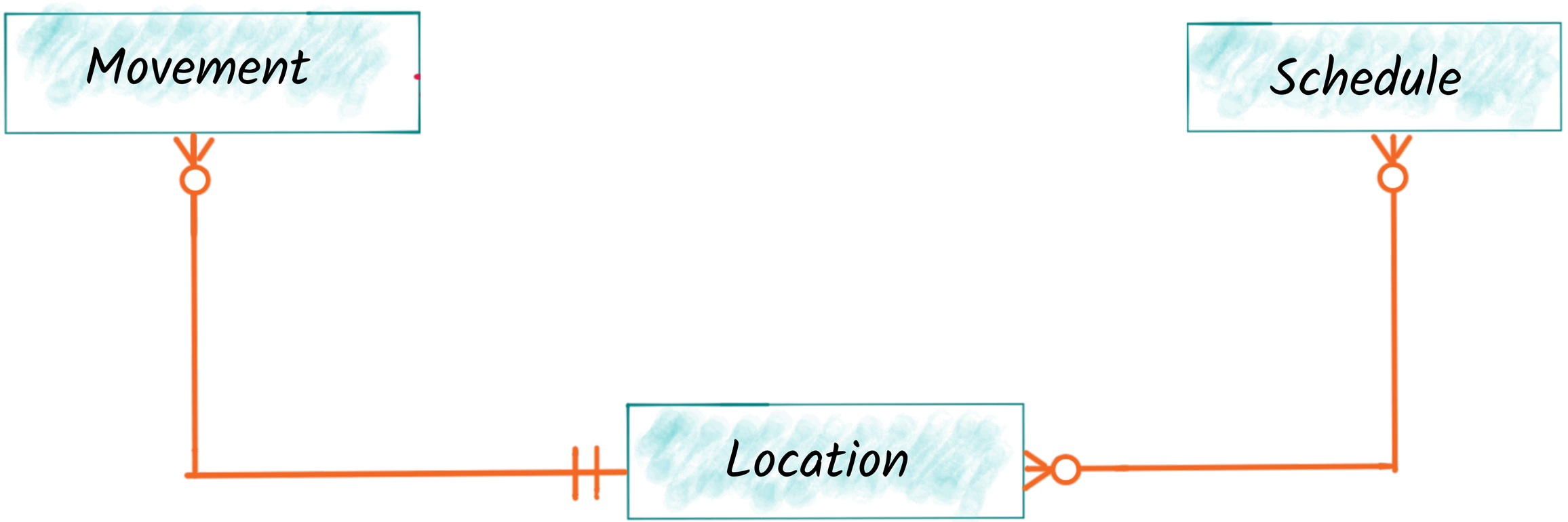
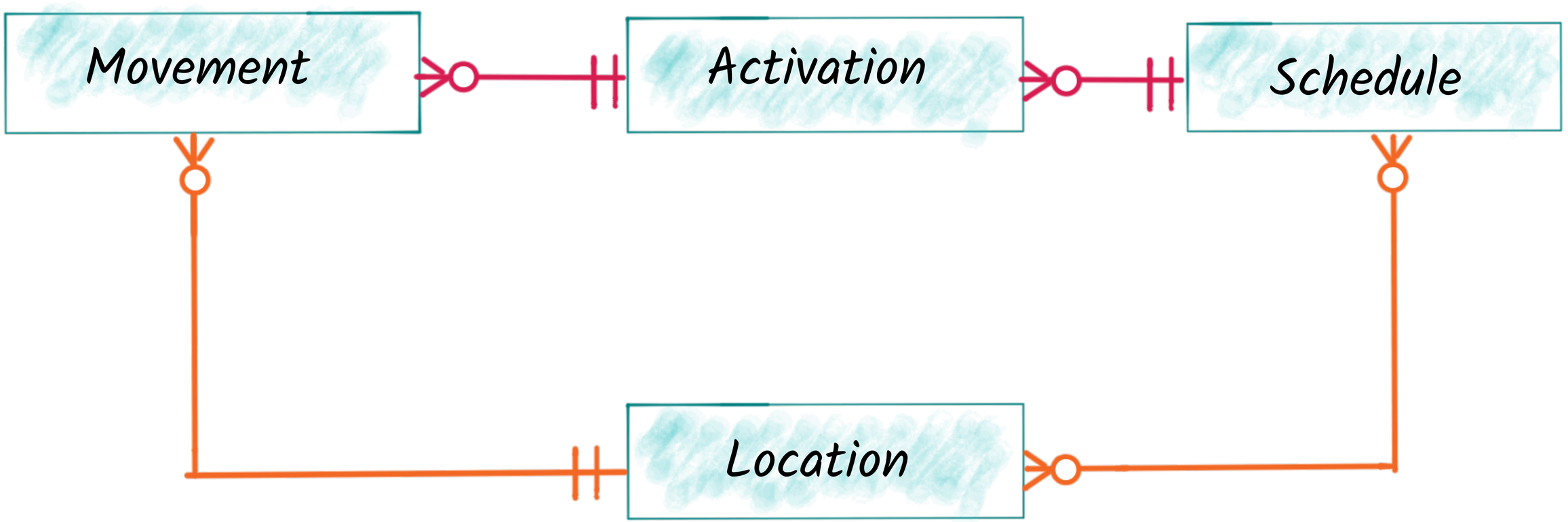
Alert configuration
REST
kafkacat
Event streaming platform

Transforming the data

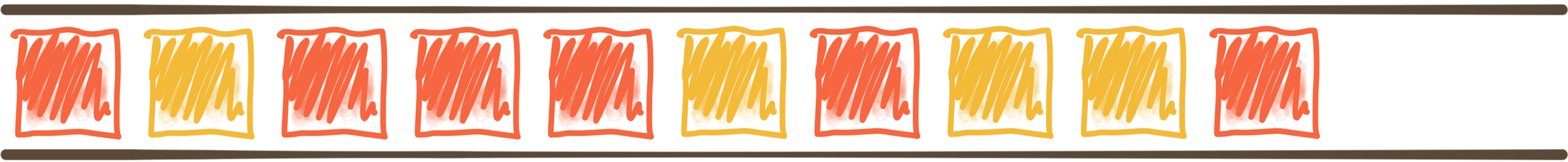
Movement


Movement
Location


Movement
Schedule
Location

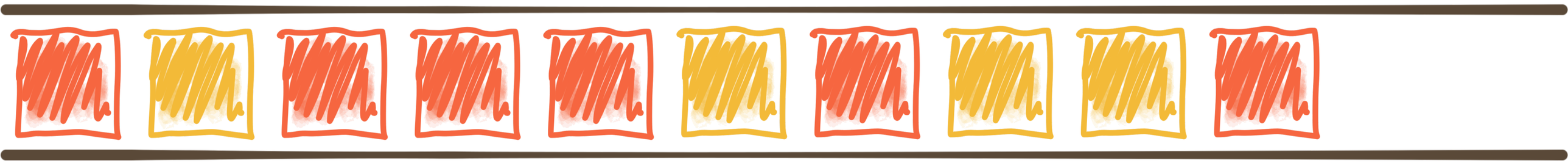

Movement
Activation
Schedule
Location

Streams of events



Time

Stream Processing with ksqlDB



Stream: widgets

Stream: widgets_red

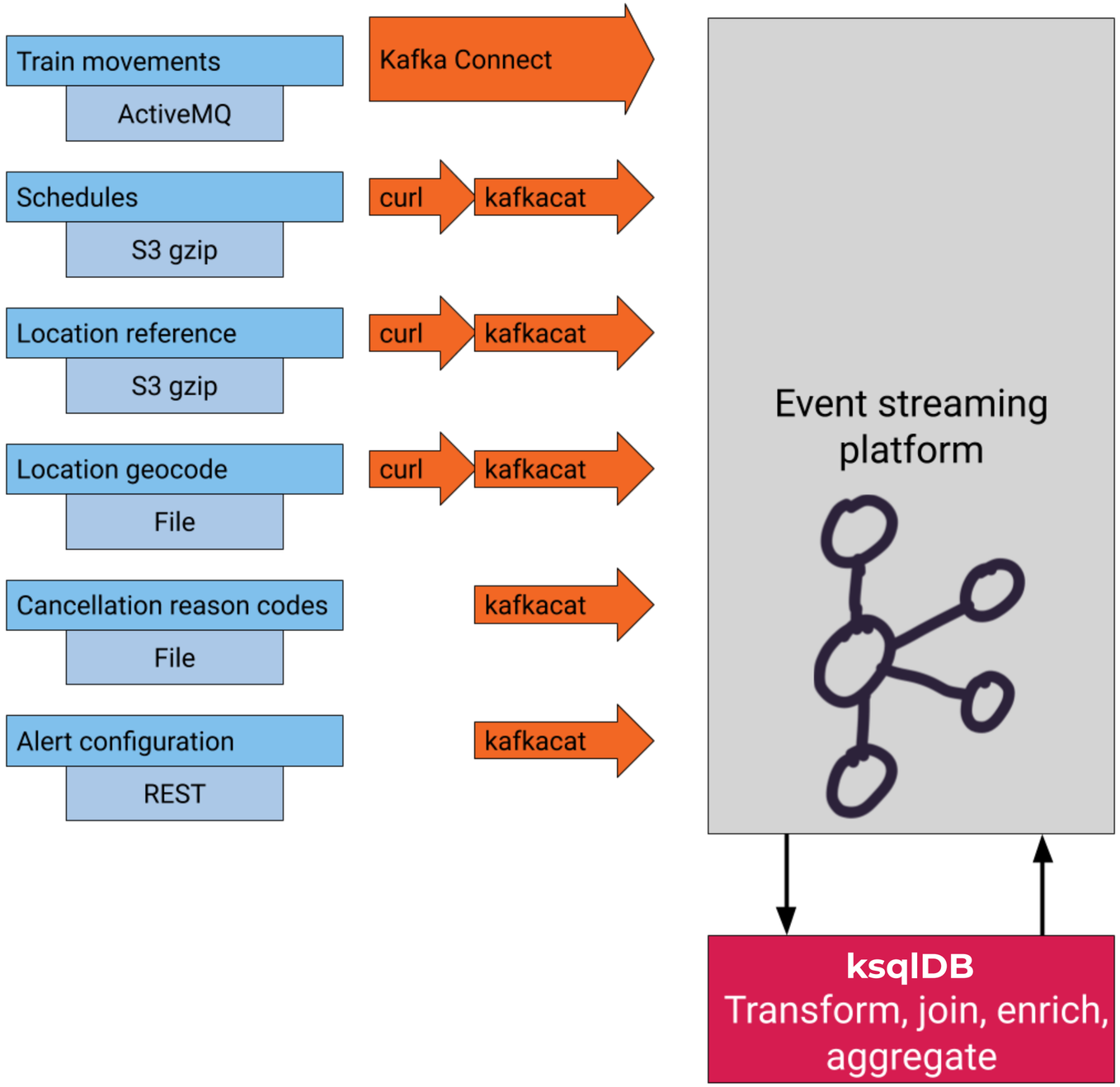
Stream Processing with ksqlDB

Stream:
widgets

KSQL

```
CREATE STREAM widgets_red AS
SELECT * FROM widgets
WHERE colour='RED';
```

Stream:
widgets_red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Location geocode
File
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kafkacat
Cancellation reason codes
File
kafkacat
Alert configuration
REST
kafkacat
Event streaming platform
ksqlDB
Transform, join, enrich, aggregate

Event data

ActiveMQ

Kafka Connect

NETWORKRAIL_TRAIN_MVT_X

- Activation
- Activation
- Cancellation
- Movement
- Movement
- Movement
- Cancellation
- Movement
- Movement

Train Movement

```
{
    "header": {
        "msg_type": "0003",
        "user_id": "#QHPA026",
        "original_
        "msg_queue
        "source_sy
    },
    "body": {
        "event_typ
        "gbtt_time
        "original_
        "planned_t
        "timetable
        "original_
        "current_t
        "delay_mon
        "next_repo
        "reporting
        "actual_ti
        "correctio
        "event_sou
        "train_fil
        "platform"
        "division_
        "train_ter
        "train_id"
        "offroute_
```

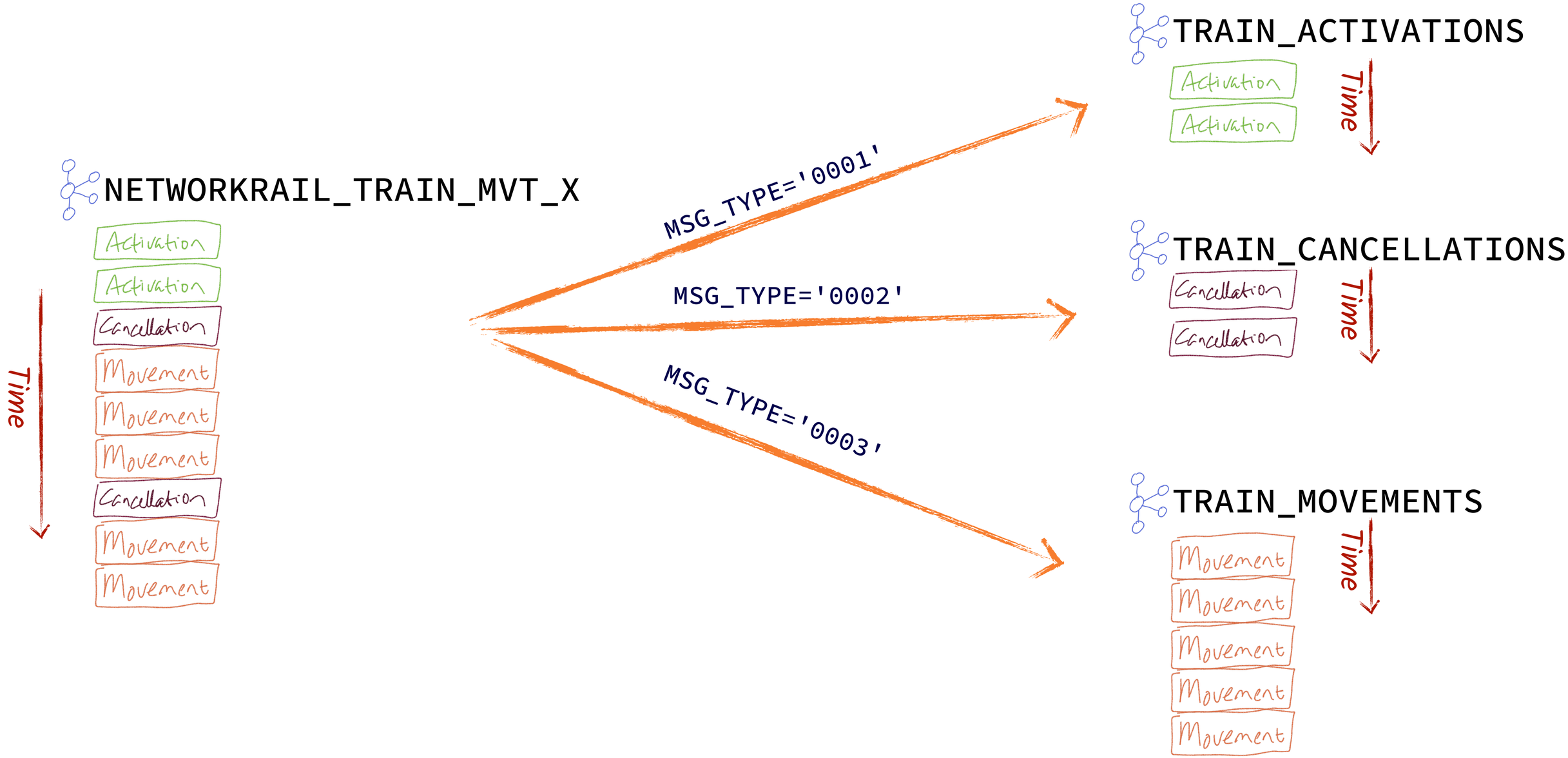
Train Cancellation

```
{
    "header": {
        "msg_type": "0002",
        "source_dev_id": "",
        "user_id": "",
        "origina
        "msg_que
        "source_
    },
    "body": {
        "train_f
        "train_s
        "orig_lo
        "toc_id"
        "dep_tim
        "divisio
        "loc_sta
        "canx_ti
        "canx_re
        "train_i
        "orig_lo
        "canx_ty
    }
}
```

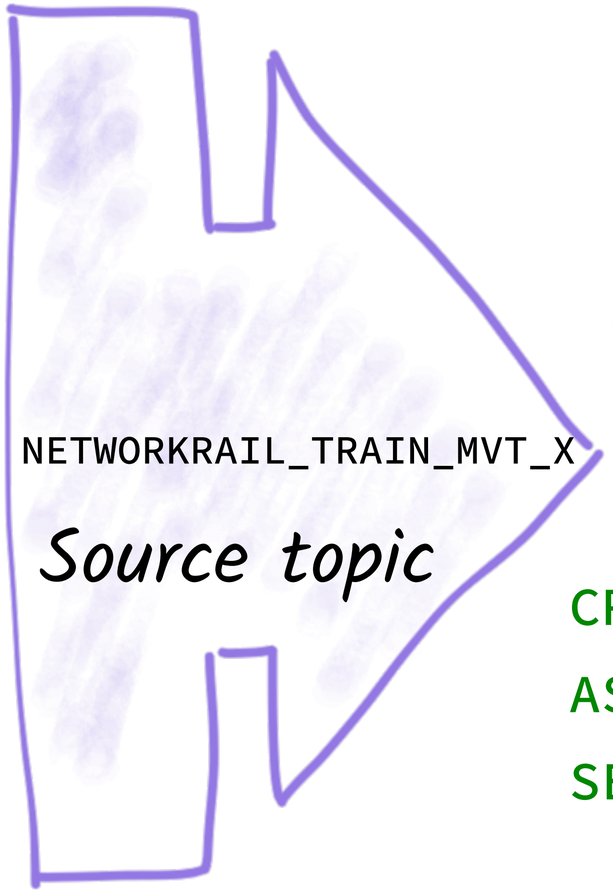
Train Activation

```
{
    "header": {
        "msg_type": "0001",
        "source_dev_id": "",
        "user_id": "",
        "original_data_source": "TSIA",
        "msg_queue_timestamp": "1511528234000",
        "source_system_id": "TRUST"
    },
    "body": {
        "schedule_source": "C",
        "train_file_address": null,
        "schedule_end_date": "2017-12-08",
        "train_id": "775F25MP24",
        "tp_origin_timestamp": "2017-11-24",
        "creation_timestamp": "1511528234000",
        "tp_origin_stanox": "",
        "origin_dep_timestamp": "1511535420000",
        "train_service_code": "25470001",
        "toc_id": "25",
```

Message routing with ksqlDB



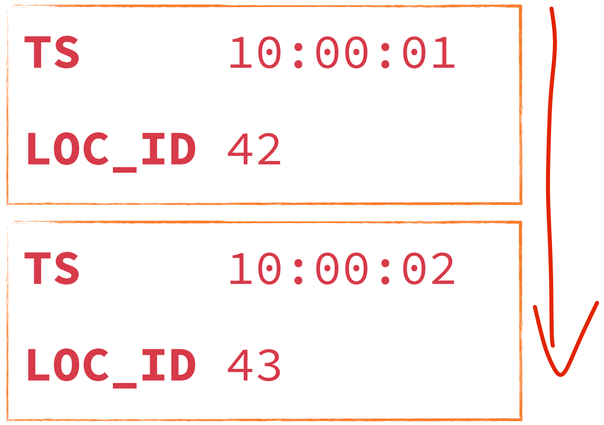
Split a stream of data (message routing)




```
CREATE STREAM TRAIN_MOVEMENTS_00
AS
SELECT *
  FROM NETWORKRAIL_TRAIN_MVT_X
WHERE header->msg_type = '0003';
```

```
CREATE STREAM TRAIN_CANCELLATIONS_00
AS
SELECT *
  FROM NETWORKRAIL_TRAIN_MVT_X
 WHERE header->msg_type = '0002';
```

Joining events to lookup data (stream-table joins)

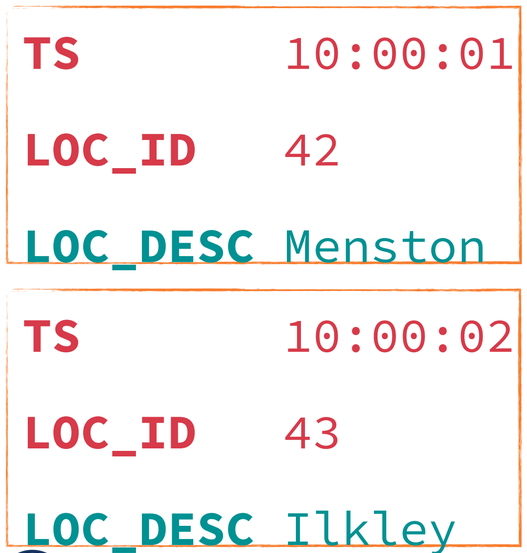


TRAIN_MOVEMENTS
(Stream)

LOCATION
(Table)

ID	DESCRIPTION
42	MENSTON
43	Ilkley

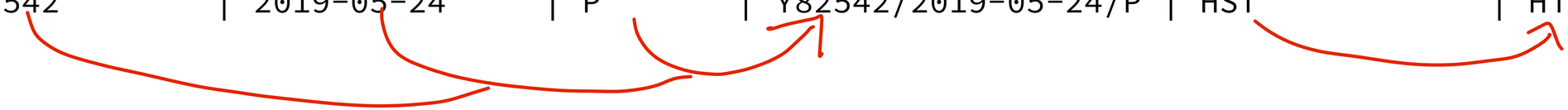
```
CREATE STREAM TRAIN_MOVEMENTS_ENRICHED AS
SELECT  TM.LOC_ID      AS LOC_ID,
        TM.TS          AS TS,
        L.DESCRIPTION AS LOC_DESC,
        […]
  FROM TRAIN_MOVEMENTS  TM
       LEFT JOIN LOCATION L
       ON TM.LOC_ID = L.ID;
```



TRAIN_MOVEMENTS_ENRICHED
(Stream)

Decode values, and generate composite key

CIF_train_uid	sched_start_dt	stp_ind	SCHEDULE_KEY	CIF_power_type	POWER_TYPE
Y82535	2019-05-20	P	Y82535/2019-05-20/P	E	Electric
Y82537	2019-05-20	P	Y82537/2019-05-20/P	DMU	Other
Y82542	2019-05-20	P	Y82542/2019-05-20/P	D	Diesel
Y82535	2019-05-24	P	Y82535/2019-05-24/P	EMU	Electric Multiple Unit
Y82542	2019-05-24	P	Y82542/2019-05-24/P	HST	High Speed Train



```
SELECT JsonScheduleV1->CIF_train_uid + '/'
        + JsonScheduleV1->schedule_start_date + '/'
        + JsonScheduleV1->CIF_stp_indicator AS SCHEDULE_KEY,
```

```
CASE
 WHEN JsonScheduleV1->schedule_segment->CIF_power_type = 'D'
   THEN  'Diesel'
 WHEN JsonScheduleV1->schedule_segment->CIF_power_type = 'E'
   THEN  'Electric'
 WHEN JsonScheduleV1->schedule_segment->CIF_power_type = 'ED'
   THEN 'Electro-Diesel'
END AS POWER_TYPE
```

Schemas

```
CREATE STREAM SCHEDULE_RAW (
              TiplocV1 STRUCT<transaction_type  VARCHAR,
                              tiploc_code       VARCHAR,
                              NALCO             VARCHAR,
                              STANOX            VARCHAR,
                              crs_code          VARCHAR,
                              description       VARCHAR,
                              tps_description VARCHAR>)
  WITH (KAFKA_TOPIC='CIF_FULL_DAILY',
        VALUE_FORMAT='JSON');
```

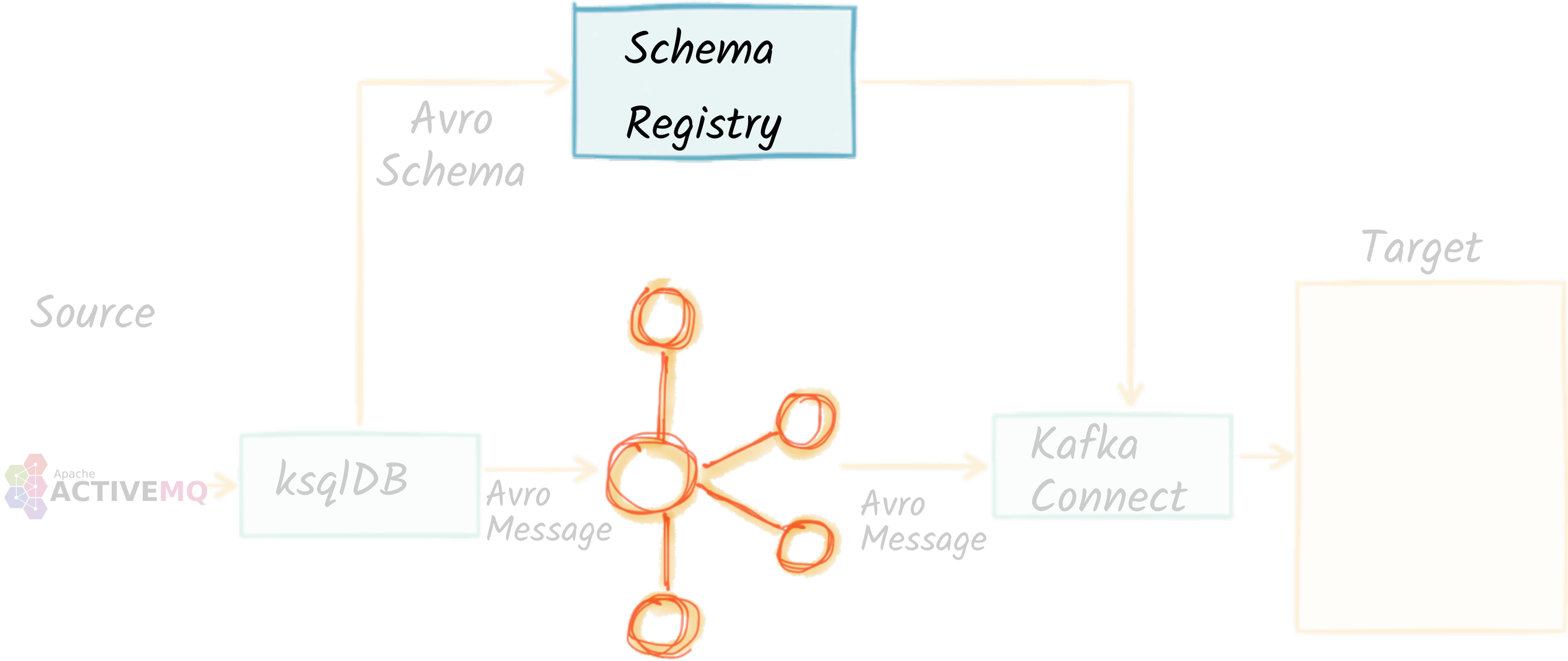
Handling JSON data

```
CREATE STREAM NETWORKRAIL_TRAIN_MVT_X (
  header STRUCT< msg_type VARCHAR, […] >,
  body VARCHAR)
  WITH (KAFKA_TOPIC='networkrail_TRAIN_MVT_X',
        VALUE_FORMAT='JSON');


CREATE STREAM TRAIN_CANCELLATIONS_00 AS
  SELECT HEADER,
         EXTRACTJSONFIELD(body,'$.canx_timestamp')   AS canx_timestamp,
         EXTRACTJSONFIELD(body,'$.canx_reason_code') AS canx_reason_code,
         […]
   FROM networkrail_TRAIN_MVT_X
  WHERE header->msg_type = '0002';
```

Declared Schema ↑

The Confluent Schema Registry



Reserialise data

```
CREATE STREAM TRAIN_CANCELLATIONS_00
  WITH (VALUE_FORMAT='AVRO') AS
  SELECT *
    FROM networkrail_TRAIN_MVT_X
  WHERE  header->msg_type = '0002';
```

Flatten and re-key a stream

```
{
  "TiplocV1": {
    "transaction_type": "Create",
    "tiploc_code": "ABWD",
    "nalco": "513100",
    "stanox": "88601",
    "crs_code": "ABW",
    "description": "ABBEY WOOD",
    "tps_description": "ABBEY WOOD"
  }
}
```

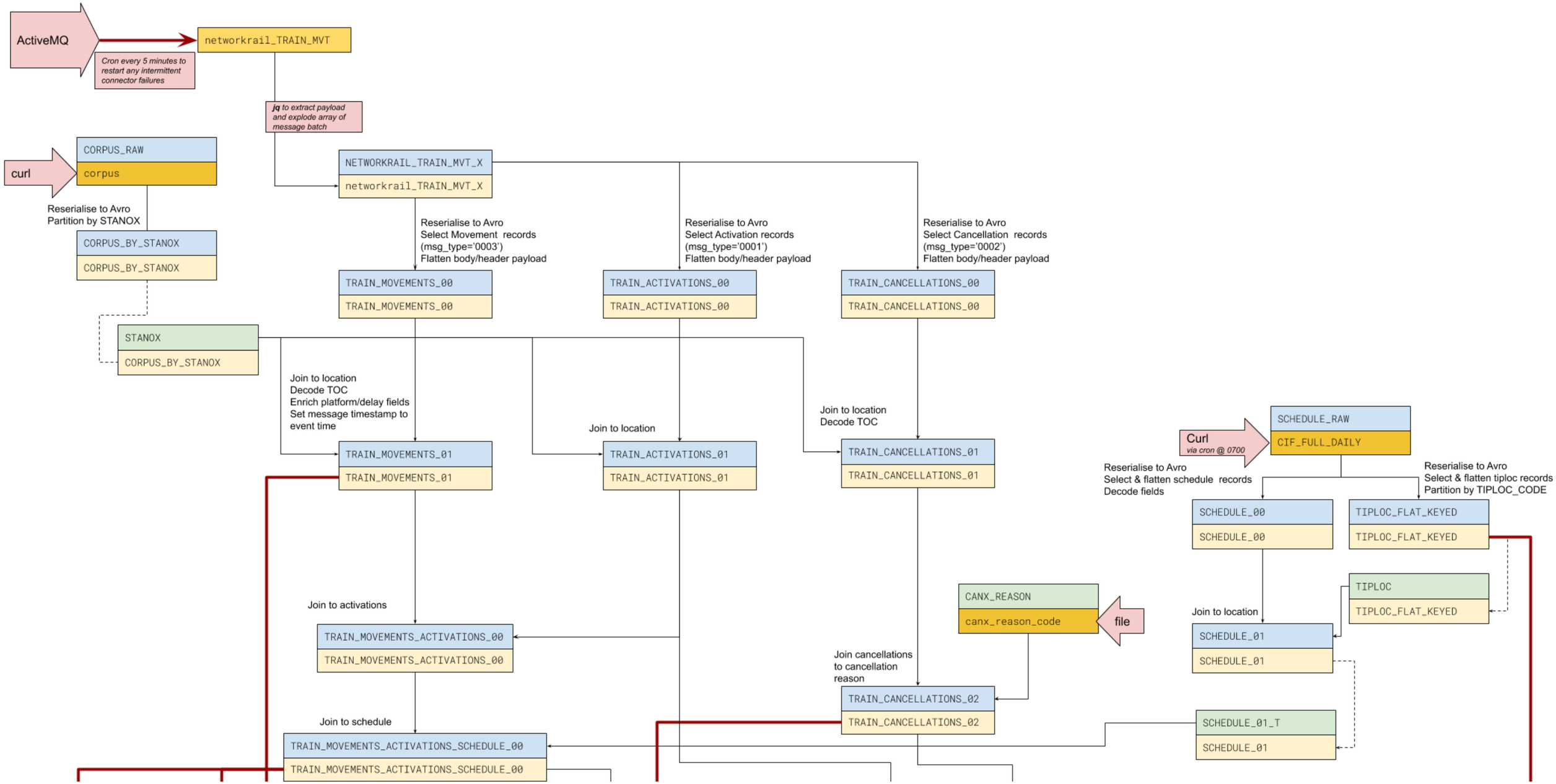
Access nested element

```
CREATE STREAM TIPLOC_FLAT_KEYED
SELECT   TiplocV1->TRANSACTION_TYPE   AS TRANSACTION_TYPE ,
         TiplocV1->TIPLOC_CODE        AS TIPLOC_CODE ,
         TiplocV1->NALCO              AS NALCO ,
         TiplocV1->STANOX             AS STANOX ,
         TiplocV1->CRS_CODE           AS CRS_CODE ,
         TiplocV1->DESCRIPTION        AS DESCRIPTION ,
         TiplocV1->TPS_DESCRIPTION    AS TPS_DESCRIPTION
FROM     SCHEDULE_RAW
PARTITION BY TIPLOC_CODE;
```

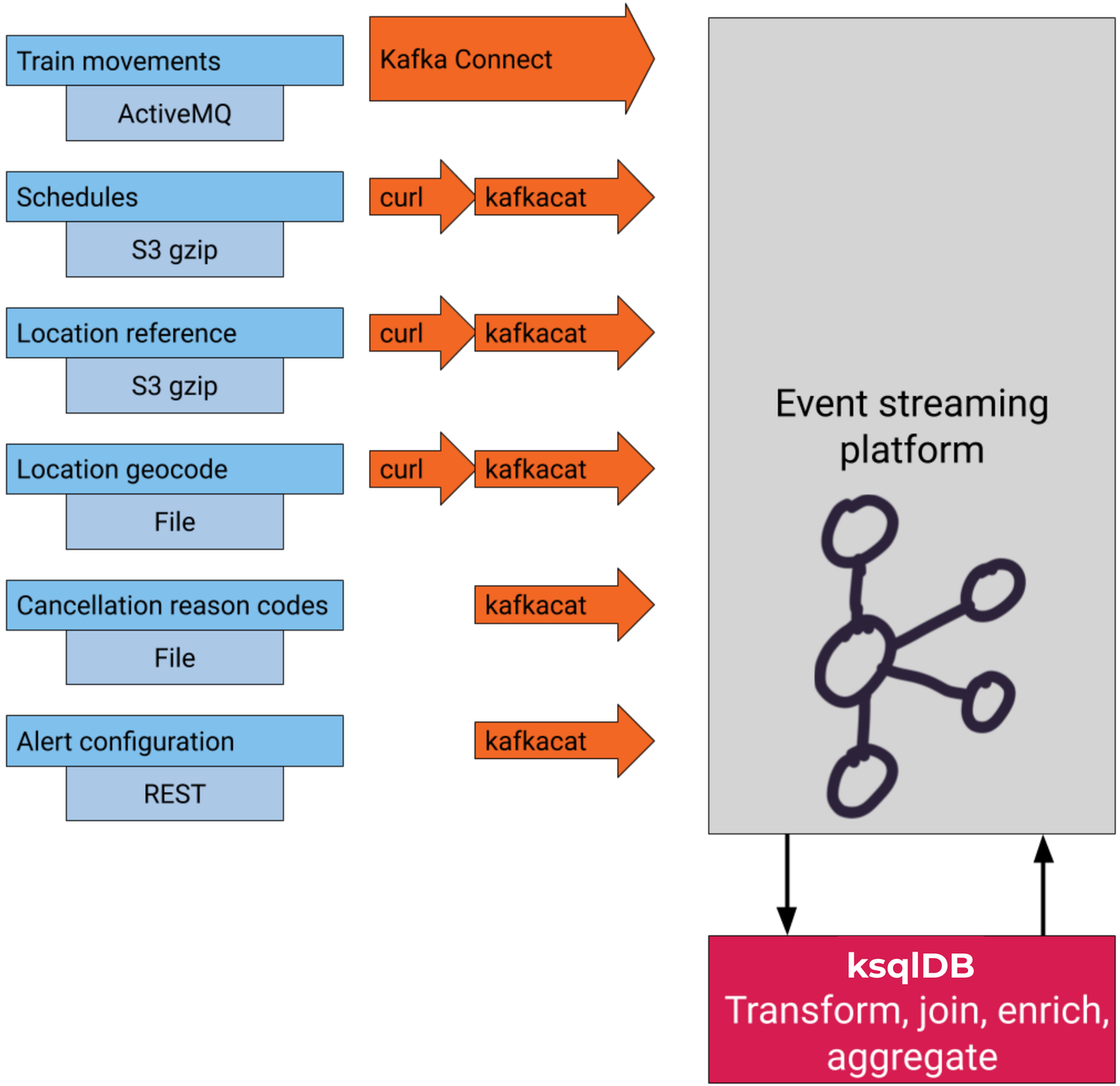
Change partitioning key

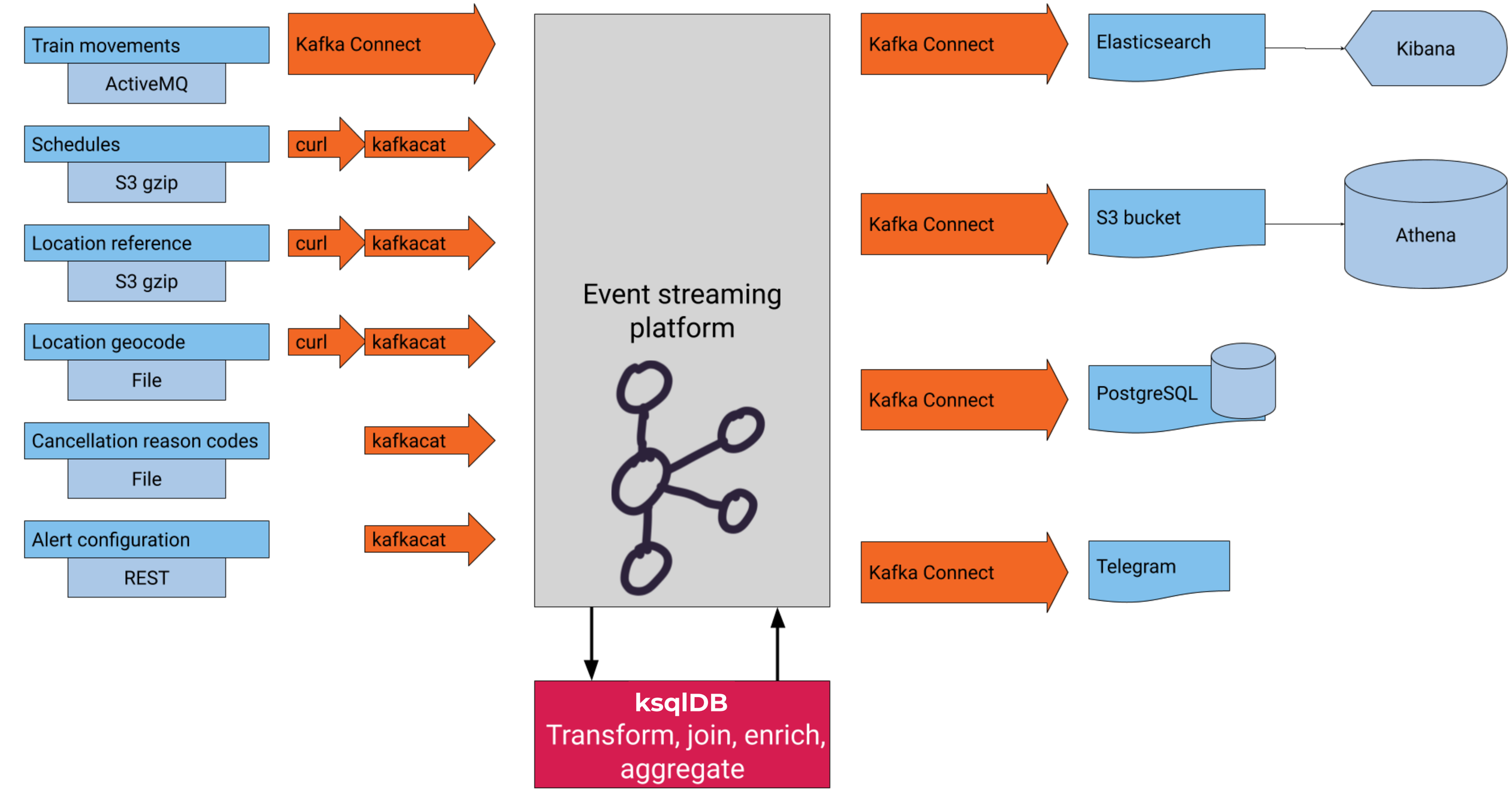
```
ksql> DESCRIBE TIPLOC_FLAT_KEYED;

Name                 : TIPLOC_FLAT_KEYED
 Field            | Type
-----------------------------------------
 TRANSACTION_TYPE | VARCHAR(STRING)
 TIPLOC_CODE      | VARCHAR(STRING)
 NALCO            | VARCHAR(STRING)
 STANOX           | VARCHAR(STRING)
 CRS_CODE         | VARCHAR(STRING)
 DESCRIPTION      | VARCHAR(STRING)
 TPS_DESCRIPTION  | VARCHAR(STRING)
-----------------------------------------
```


ActiveMQ
networkrail_TRAIN_MVT
Cron every 5 minutes to restart any intermittent connector failures
jq to extract payload and explode array of message batch
curl
CORPUS_RAW
corpus
Reserialise to Avro
Partition by STANOX
CORPUS_BY_STANOX
CORPUS_BY_STANOX
STANOX
CORPUS_BY_STANOX
NETWORKRAIL_TRAIN_MVT_X
networkrail_TRAIN_MVT_X
Reserialise to Avro
Select Movement records
(msg_type='0003')
Flatten body/header payload
Reserialise to Avro
Select Activation records
(msg_type='0001')
Flatten body/header payload
Reserialise to Avro
Select Cancellation records
(msg_type='0002')
Flatten body/header payload
TRAIN_MOVEMENTS_00
TRAIN_MOVEMENTS_00
TRAIN_ACTIVATIONS_00
TRAIN_ACTIVATIONS_00
TRAIN_CANCELLATIONS_00
TRAIN_CANCELLATIONS_00
Join to location
Decode TOC
Enrich platform/delay fields
Set message timestamp to
event time
Join to location
Join to location
Decode TOC
TRAIN_MOVEMENTS_01
TRAIN_MOVEMENTS_01
TRAIN_ACTIVATIONS_01
TRAIN_ACTIVATIONS_01
TRAIN_CANCELLATIONS_01
TRAIN_CANCELLATIONS_01
Curl
via cron @ 0700
SCHEDULE_RAW
CIF_FULL_DAILY
Reserialise to Avro
Select & flatten schedule records
Decode fields
Reserialise to Avro
Select & flatten tiploc records
Partition by TIPLOC_CODE
SCHEDULE_00
SCHEDULE_00
TIPLOC_FLAT_KEYED
TIPLOC_FLAT_KEYED
TIPLOC
TIPLOC_FLAT_KEYED
Join to activations
CANX_REASON
canx_reason_code
file
Join to location
TRAIN_MOVEMENTS_ACTIVATIONS_00
TRAIN_MOVEMENTS_ACTIVATIONS_00
SCHEDULE_01
SCHEDULE_01
Join cancellations
to cancellation
reason
TRAIN_CANCELLATIONS_02
TRAIN_CANCELLATIONS_02
Join to schedule
SCHEDULE_01_T
SCHEDULE_01
TRAIN_MOVEMENTS_ACTIVATIONS_SCHEDULE_00
TRAIN_MOVEMENTS_ACTIVATIONS_SCHEDULE_00

Using the data


Train movements
ActiveMQ
Kafka Connect
Schedules
S3 gzip
curl
kafkacat
Location reference
S3 gzip
curl
kafkacat
Location geocode
File
curl
kafkacat
Cancellation reason codes
File
kafkacat
Alert configuration
REST
kafkacat
Event streaming platform
ksqlDB
Transform, join, enrich, aggregate


Train movements
ActiveMQ
Kafka Connect
Schedules
S3 gzip
curl
kafkacat
Location reference
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curl
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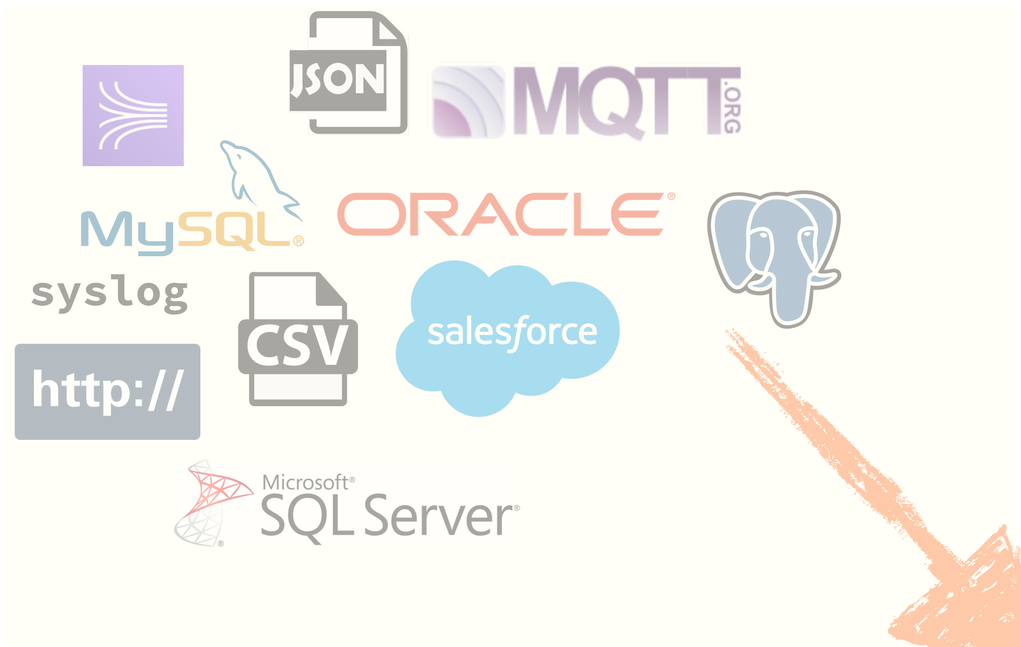
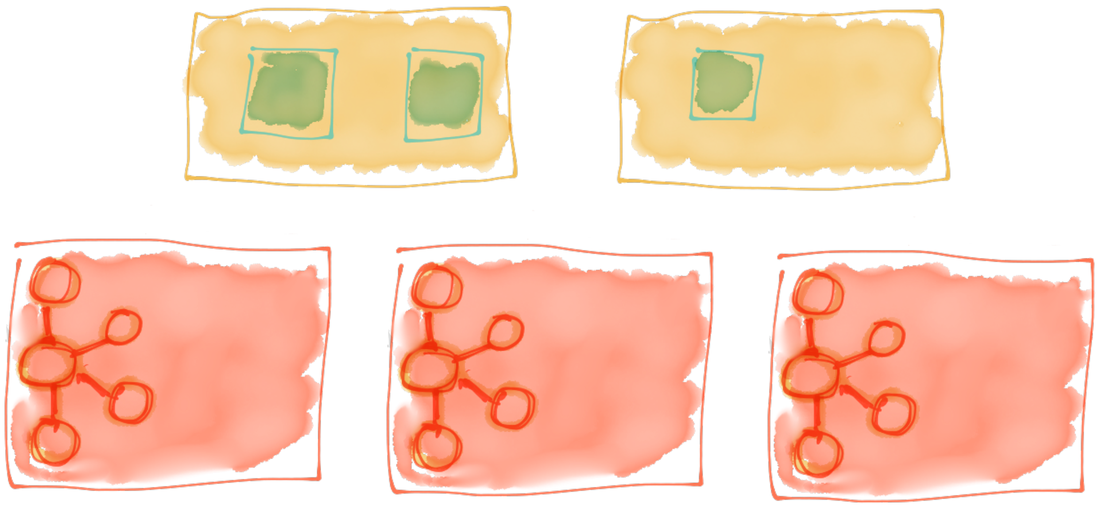
Location geocode
File
curl
kafkacat
Cancellation reason codes
File
kafkacat
Alert configuration
REST
kafkacat
Event streaming platform
ksqlDB
Transform, join, enrich, aggregate
Kafka Connect
Elasticsearch
Kibana
Kafka Connect
S3 bucket
Athena
Kafka Connect
PostgreSQL
Kafka Connect
Telegram

Streaming Integration with Kafka Connect

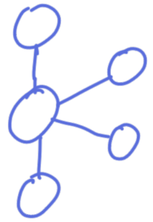




Kafka Connect

Kafka Brokers

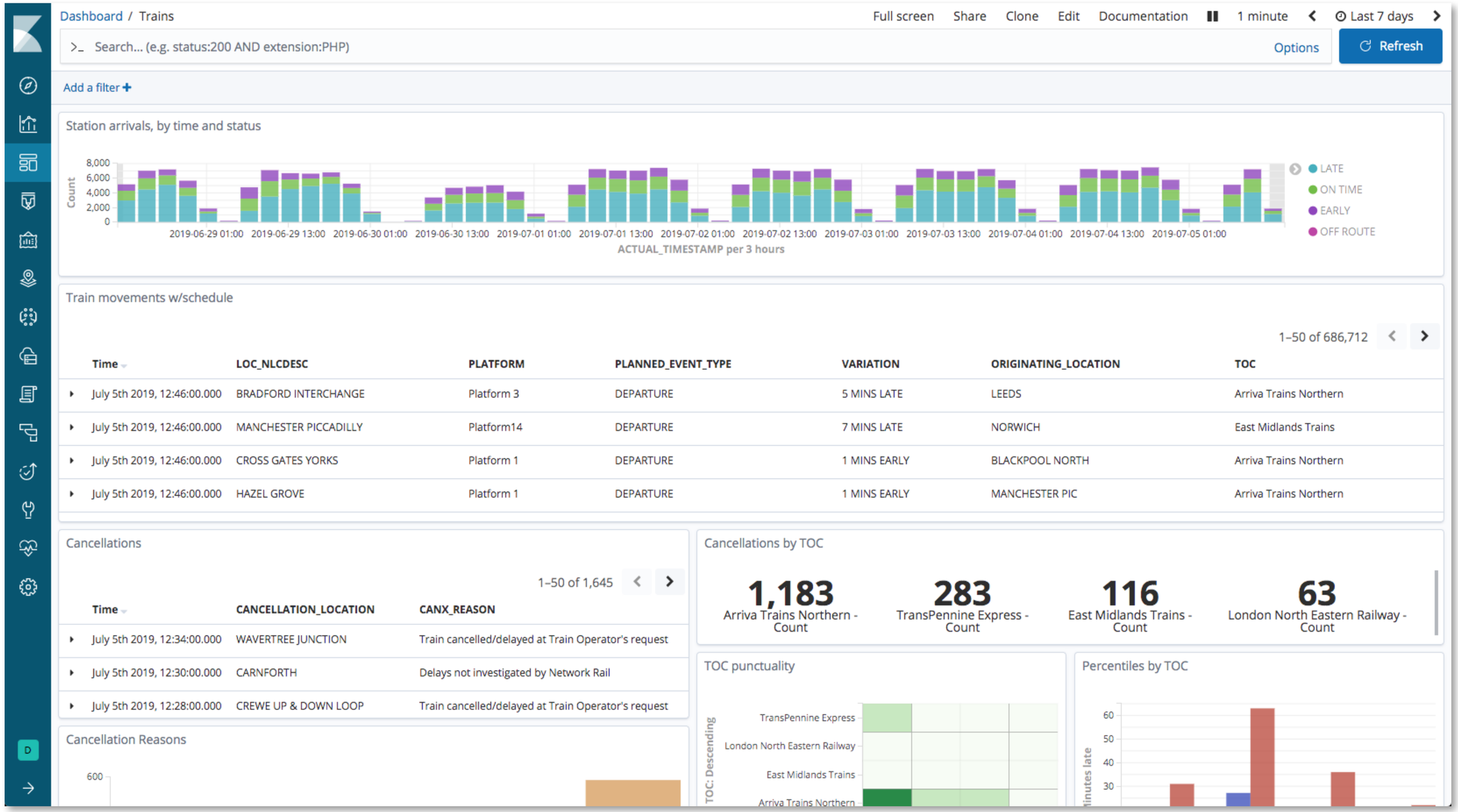
Kafka -> Elasticsearch



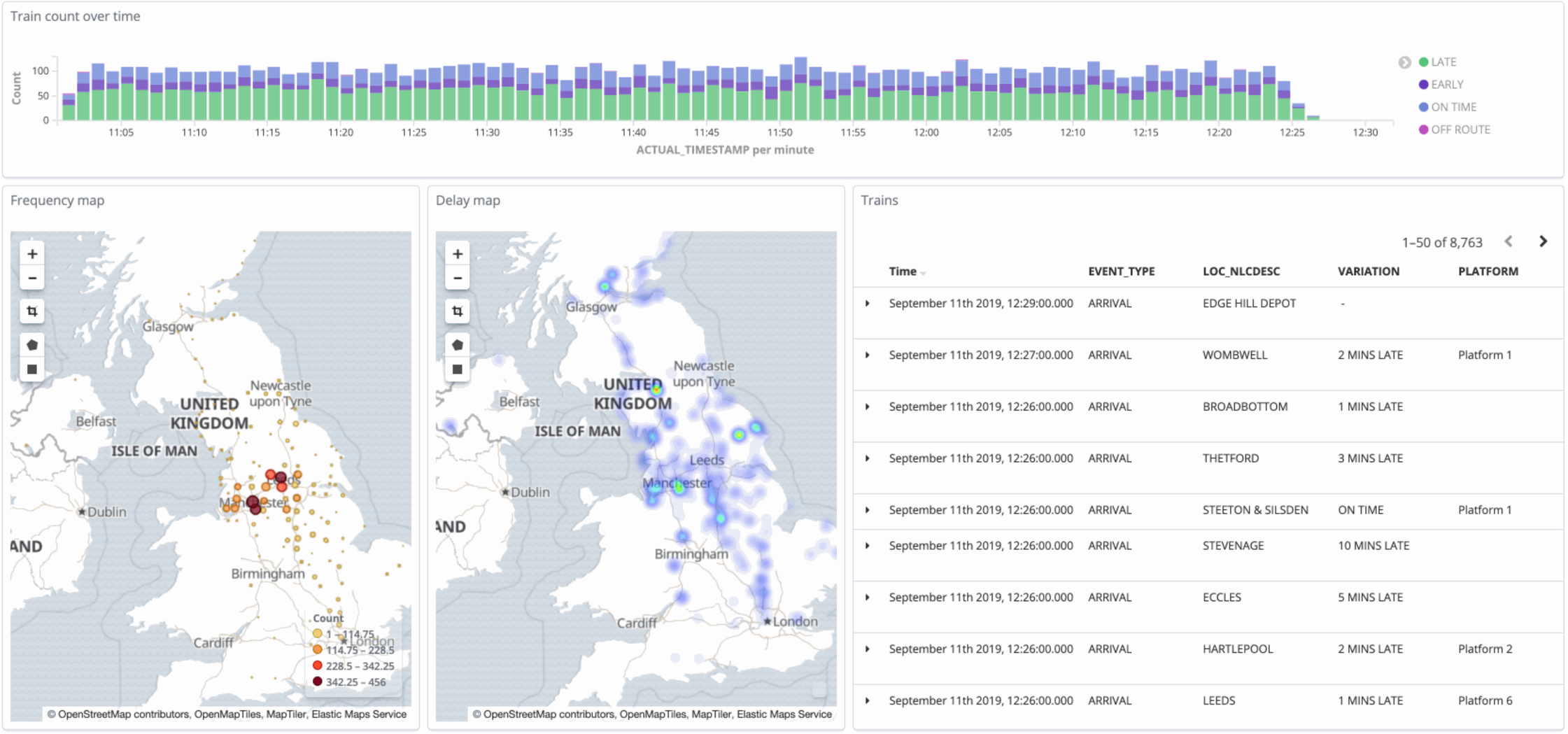
elasticsearch

```
{
    "connector.class": "io.confluent.connect.elasticsearch.ElasticsearchSinkConnector",
    "topics": "TRAIN_MOVEMENTS_ACTIVATIONS_SCHEDULE_00",
    "connection.url": "http://elasticsearch:9200",
    "type.name": "type.name=kafkaconnect",
    "key.ignore": "false",
    "schema.ignore": "true",
    "key.converter": "org.apache.kafka.connect.storage.StringConverter"
}
```

Kibana for real-time visualisation of rail data



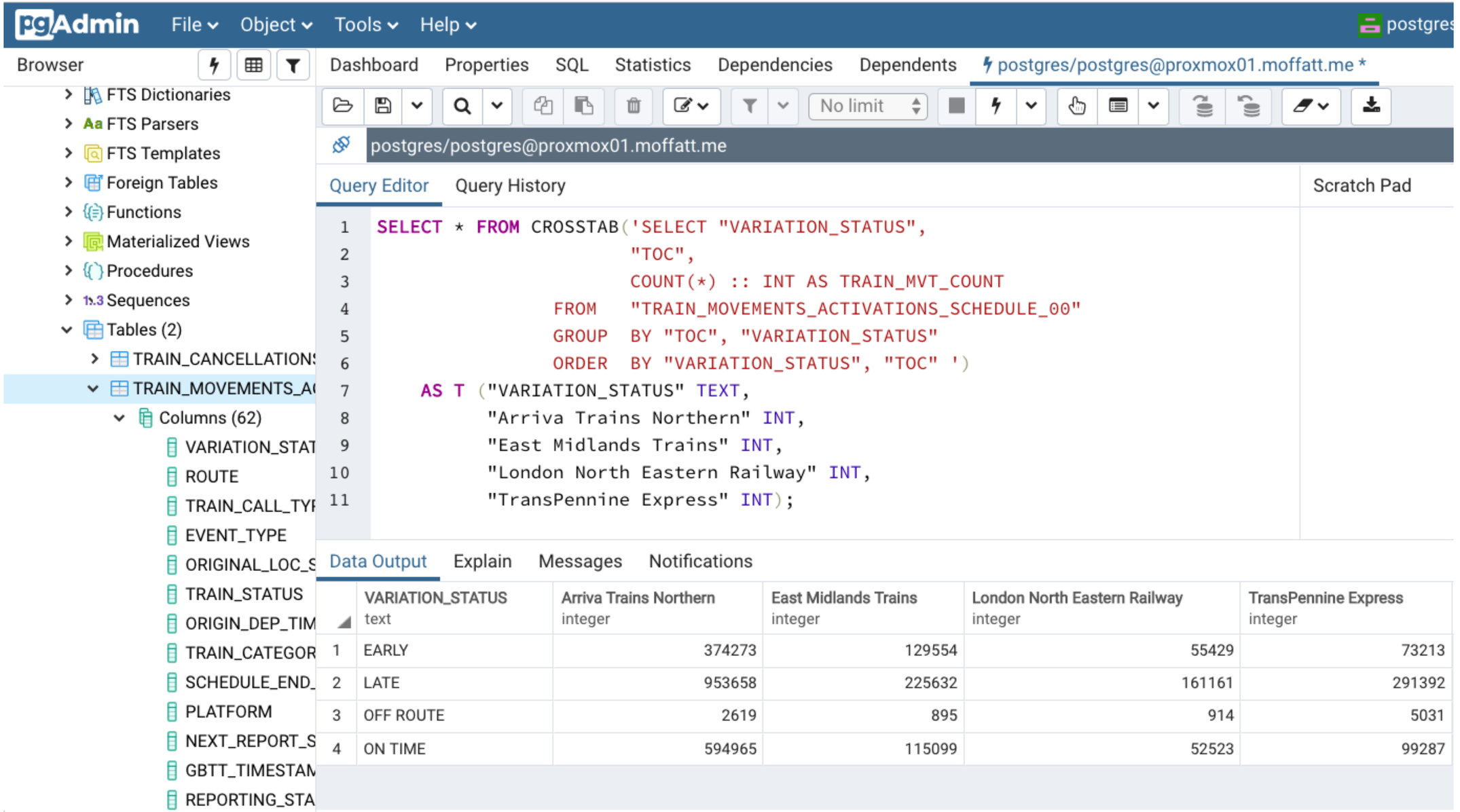
Kibana for real-time analysis of rail data



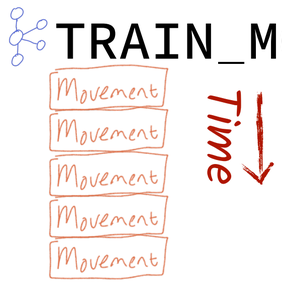
Kafka -> Postgres

```
{
 "connector.class": "io.confluent.connect.jdbc.JdbcSinkConnector",
 "key.converter": "org.apache.kafka.connect.storage.StringConverter",
 "connection.url": "jdbc:postgresql://postgres:5432/",
 "connection.user": "postgres",
 "connection.password": "postgres",
 "auto.create": true,
 "auto.evolve": true,
 "insert.mode": "upsert",
 "pk.mode": "record_key",
 "pk.fields": "MESSAGE_KEY",
 "topics": "TRAIN_MOVEMENTS_ACTIVATIONS_SCHEDULE_00",
 "transforms": "dropArrays",
 "transforms.dropArrays.type": "org.apache.kafka.connect.transforms.ReplaceField$Value",
 "transforms.dropArrays.blacklist": "SCHEDULE_SEGMENT_LOCATION, HEADER"
}
```

Kafka -> Postgres



But do you even need a database?



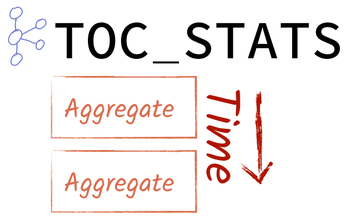
Kafka

```
SELECT TIMESTAMPTOSTRING(WINDOWSTART(),'yyyy-MM-dd') AS WINDOW_START_TS, VARIATION_STATUS,
       SUM(CASE WHEN TOC = 'Arriva Trains Northern'         THEN 1 ELSE 0 END) AS Arriva_CT,
       SUM(CASE WHEN TOC = 'East Midlands Trains'           THEN 1 ELSE 0 END) AS EastMidlands_CT,
       SUM(CASE WHEN TOC = 'London North Eastern Railway' THEN 1 ELSE 0 END) AS LNER_CT,
       SUM(CASE WHEN TOC = 'TransPennine Express'           THEN 1 ELSE 0 END) AS TransPennineExpress_CT
 FROM  TRAIN_MOVEMENTS WINDOW TUMBLING (SIZE 1 DAY)
GROUP BY VARIATION_STATUS;
```

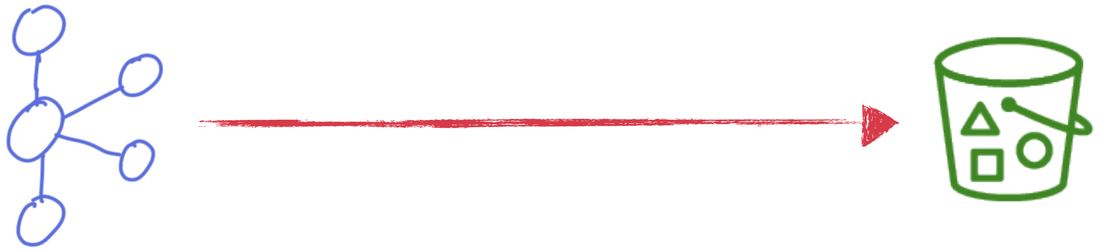
KSQL

Date	Variation	Arriva	East Mid	LNER	TPE
2019-07-02	OFF ROUTE	46	78	20	167
2019-07-02	ON TIME	19083	3568	1509	2916
2019-07-02	LATE	30850	7953	5420	9042
2019-07-02	EARLY	11478	3518	1349	2096
2019-07-03	OFF ROUTE	79	25	41	213
2019-07-03	ON TIME	19512	4247	1915	2936
2019-07-03	LATE	37357	8258	5342	11016
2019-07-03	EARLY	11825	4574	1888	2094

Kafka



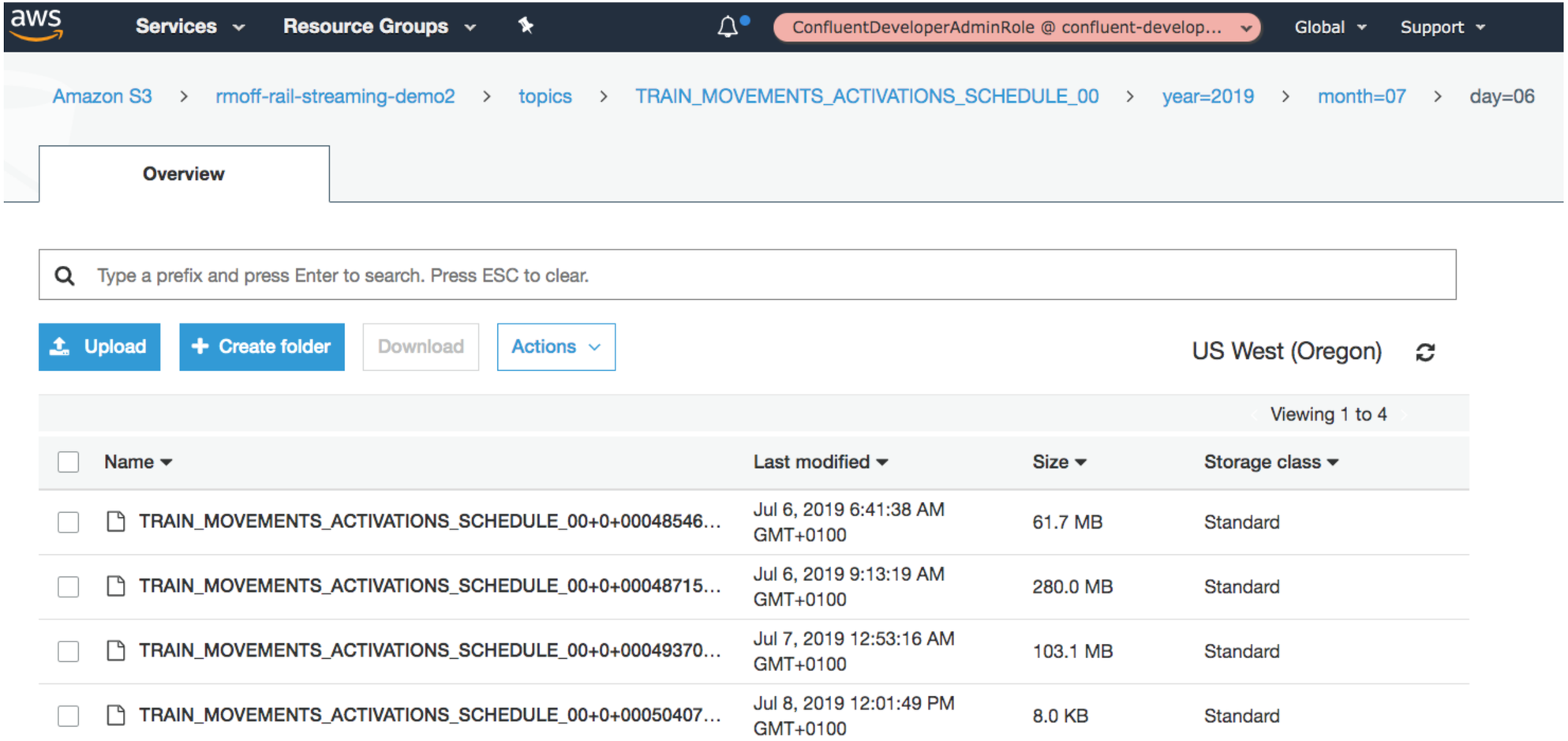
Kafka -> S3



```
{
   "connector.class": "io.confluent.connect.s3.S3SinkConnector",
   "key.converter":"org.apache.kafka.connect.storage.StringConverter",
   "tasks.max": "1",
   "topics": "TRAIN_MOVEMENTS_ACTIVATIONS_SCHEDULE_00",
   "s3.region": "us-west-2",
   "s3.bucket.name": "rmoff-rail-streaming-demo",
   "flush.size": "65536",
   "storage.class": "io.confluent.connect.s3.storage.S3Storage",
   "format.class": "io.confluent.connect.s3.format.avro.AvroFormat",
   "schema.generator.class": "io.confluent.connect.storage.hive.schema.DefaultSchemaGenerator",
   "schema.compatibility": "NONE",
   "partitioner.class": "io.confluent.connect.storage.partitioner.TimeBasedPartitioner",
   "path.format":"\'year\'=YYYY/\'month\'=MM/\'day\'=dd",
   "timestamp.extractor":"Record",
   "partition.duration.ms": 1800000,
   "locale":"en",
   "timezone": "UTC"
 }
```

Kafka -> S3

```
$ aws s3 ls s3://rmoff-rail-streaming-demo/topics/TRAIN_MOVEMENTS_ACTIVATIONS_SCHEDULE_00/year=2019/month=07/day=07/
2019-07-07 10:05:41  200995548 TRAIN_MOVEMENTS_ACTIVATIONS_SCHEDULE_00+0+0004963416.avro
2019-07-07 19:47:11   87631494 TRAIN_MOVEMENTS_ACTIVATIONS_SCHEDULE_00+0+0005007151.avro
```



Analysis with AWS Athena

explode schedule d... | New query 2 | +

```
1  SELECT train_id,
2         DATE_FORMAT(FROM_UNIXTIME(actual_timestamp/1000),
3              '%Y-%m-%dT%H:%i:%sZ') AS actual_ts,
4         loc_nlcdesc,
5         json_extract(element_at(SCHEDULE_SEGMENT_LOCATION,-1),
6                      '$.tiploc_code') AS last_station
7  FROM TRAIN_MOVEMENTS_ACTIVATIONS_SCHEDULE_00
8  WHERE year = '2019'
9          AND month='06'
10         AND day = '23'
11         AND originating_location='ILKLEY'
12 LIMIT 50;
```

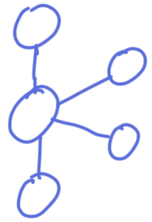
Run query | Save as | Create | (Run time: 6.01 seconds, Data scanned: 82.85 MB)

Use Ctrl + Enter to run query, Ctrl + Space to autocomplete | Format query | Clear

Results

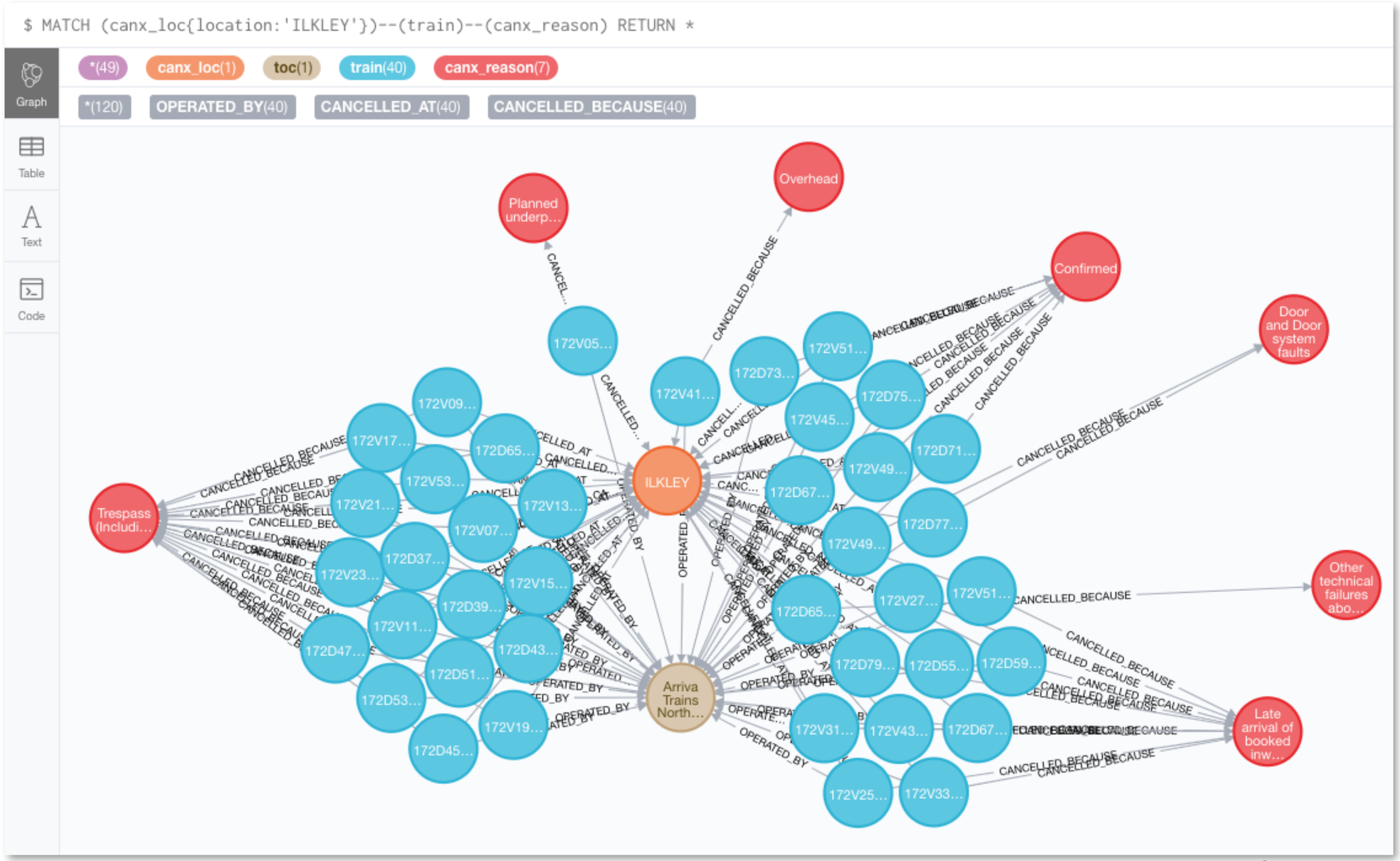
	train_id	actual_ts	loc_nlcdesc	last_station
1	172V31MD23	2019-06-23T08:44:00Z	GUISELEY	"LEEDS"
2	172V33ME23	2019-06-23T09:39:00Z	APPERLEY JN	"LEEDS"
3	172V33ME23	2019-06-23T09:35:00Z	GUISELEY	"LEEDS"

Graph analysis

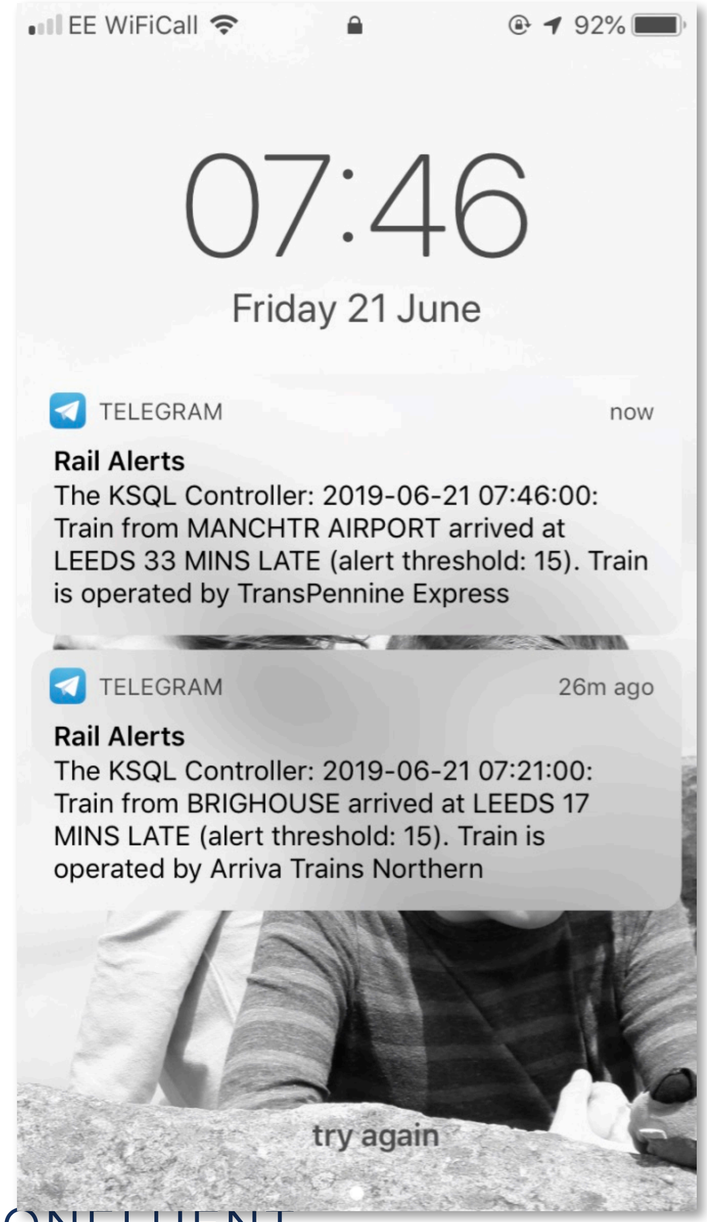


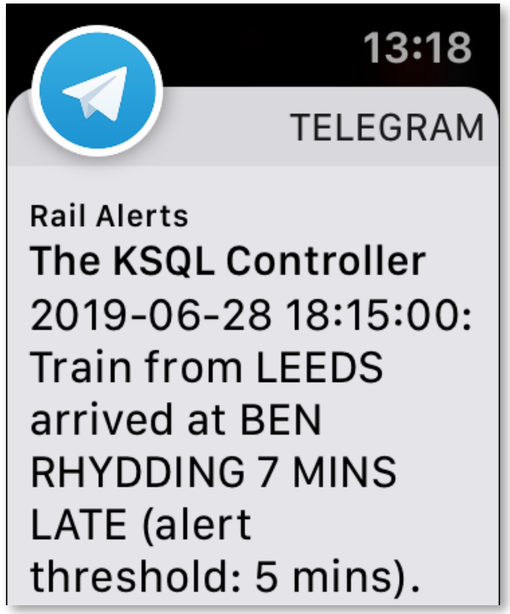
```
{
    "connector.class": "streams.kafka.connect.sink.Neo4jSinkConnector",
    "topics": "TRAIN_CANCELLATIONS_02",
    "key.converter":"org.apache.kafka.connect.storage.StringConverter",
    "errors.tolerance": "all",
    "errors.deadletterqueue.topic.name": "sink-neo4j-train-00_dlq",
    "errors.deadletterqueue.topic.replication.factor": 1,
    "errors.deadletterqueue.context.headers.enable":true,
    "neo4j.server.uri": "bolt://neo4j:7687",
    "neo4j.authentication.basic.username": "neo4j",
    "neo4j.authentication.basic.password": "connect",
    "neo4j.topic.cypher.TRAIN_CANCELLATIONS_02": "MERGE (train:train{id: event.TRAIN_ID}) MERGE
(toc:toc{toc: event.TOC}) MERGE (canx_reason:canx_reason{reason: event.CANX_REASON}) MERGE
(canx_loc:canx_loc{location: coalesce(event.CANCELLATION_LOCATION,\'<unknown>\')}) MERGE (train)-
[:OPERATED_BY]->(toc) MERGE (canx_loc)<-[:CANCELLED_AT{reason:event.CANX_REASON,
time:event.CANX_TIMESTAMP}]-(train)-[:CANCELLED_BECAUSE]->(canx_reason)"
      }
```

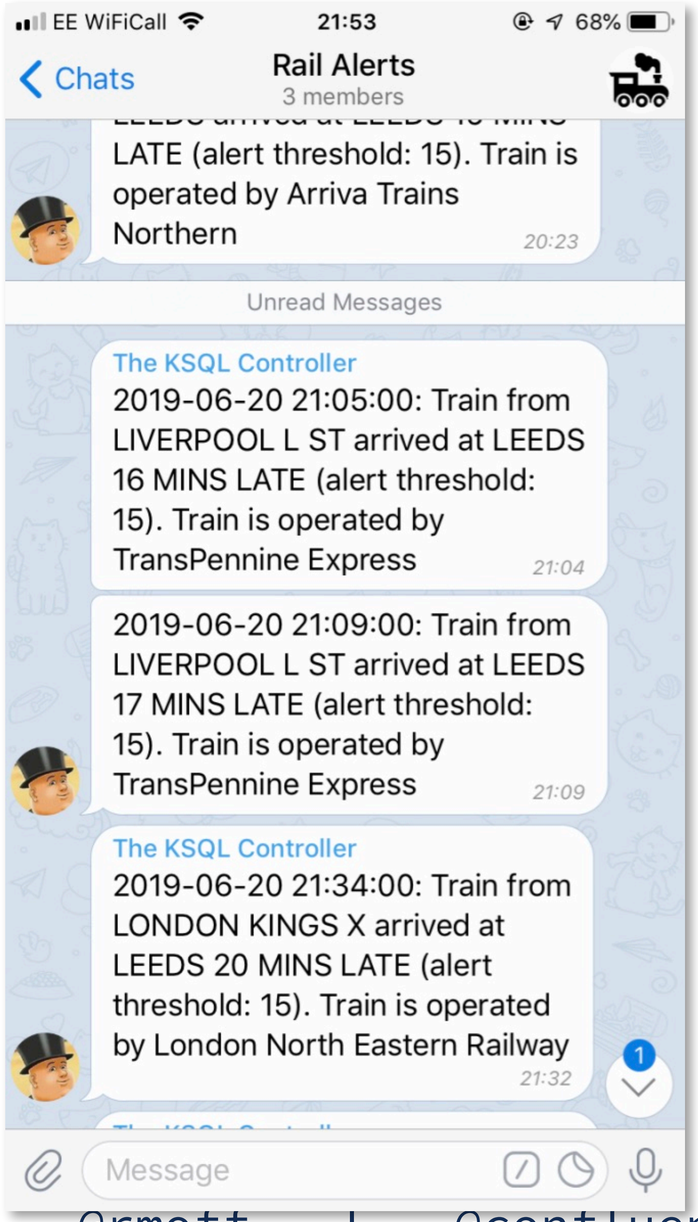
Graph relationships



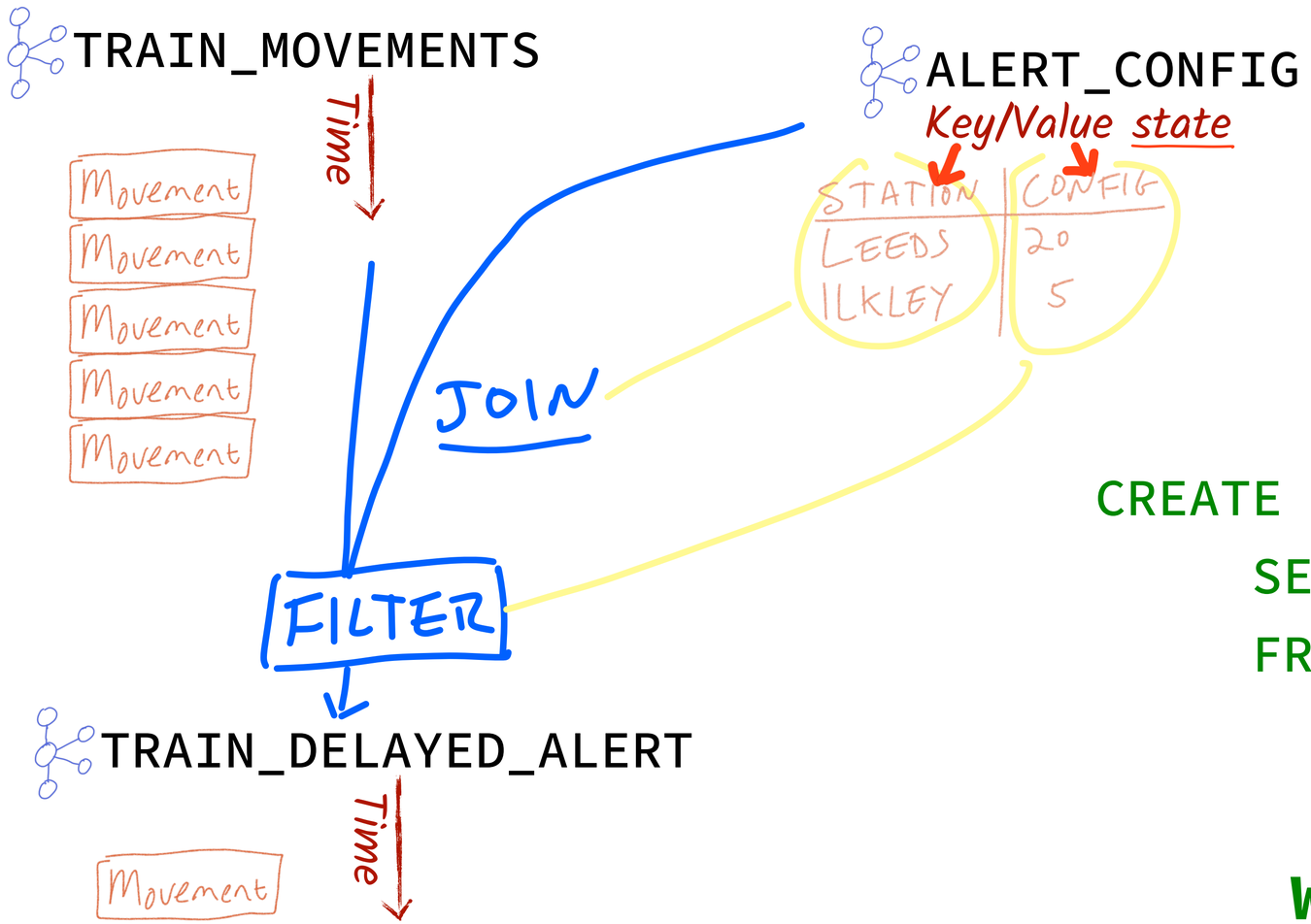
Tell me when trains are delayed at my station







Event-driven Alerting - logic

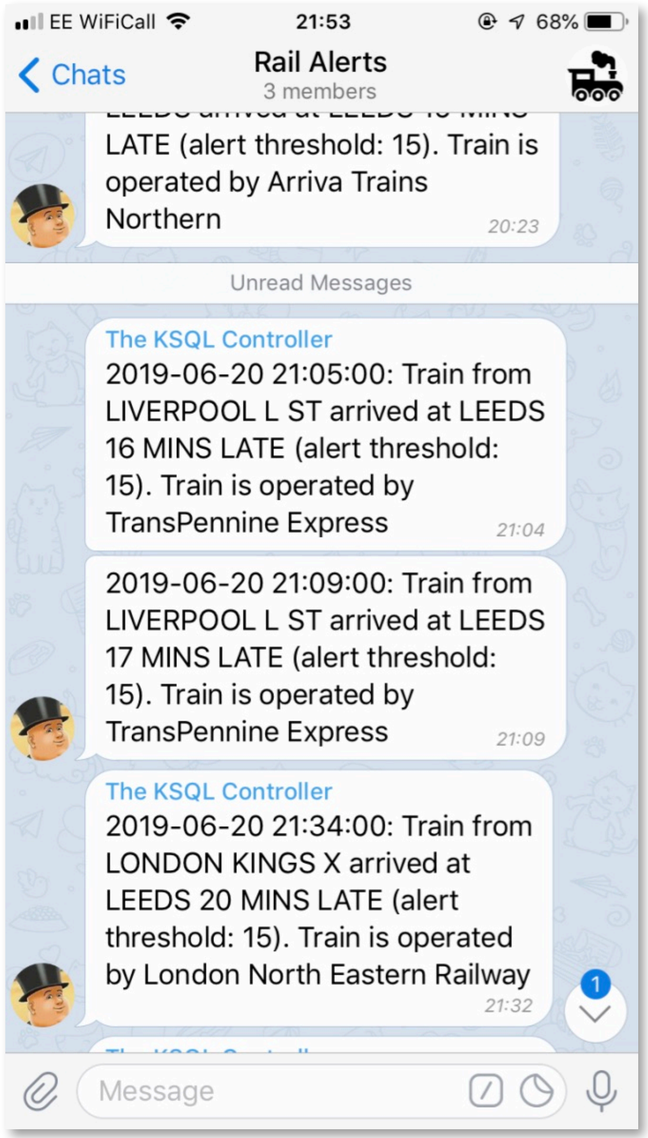



```
CREATE STREAM TRAINS_DELAYED_ALERT AS
      SELECT […]
      FROM TRAIN_MOVEMENTS T
           INNER JOIN ALERT_CONFIG A
           ON T.LOC_NLCDESC = A.STATION
    WHERE TIMETABLE_VARIATION
                > A.ALERT_OVER_MINS;
```

Sending messages to Telegram

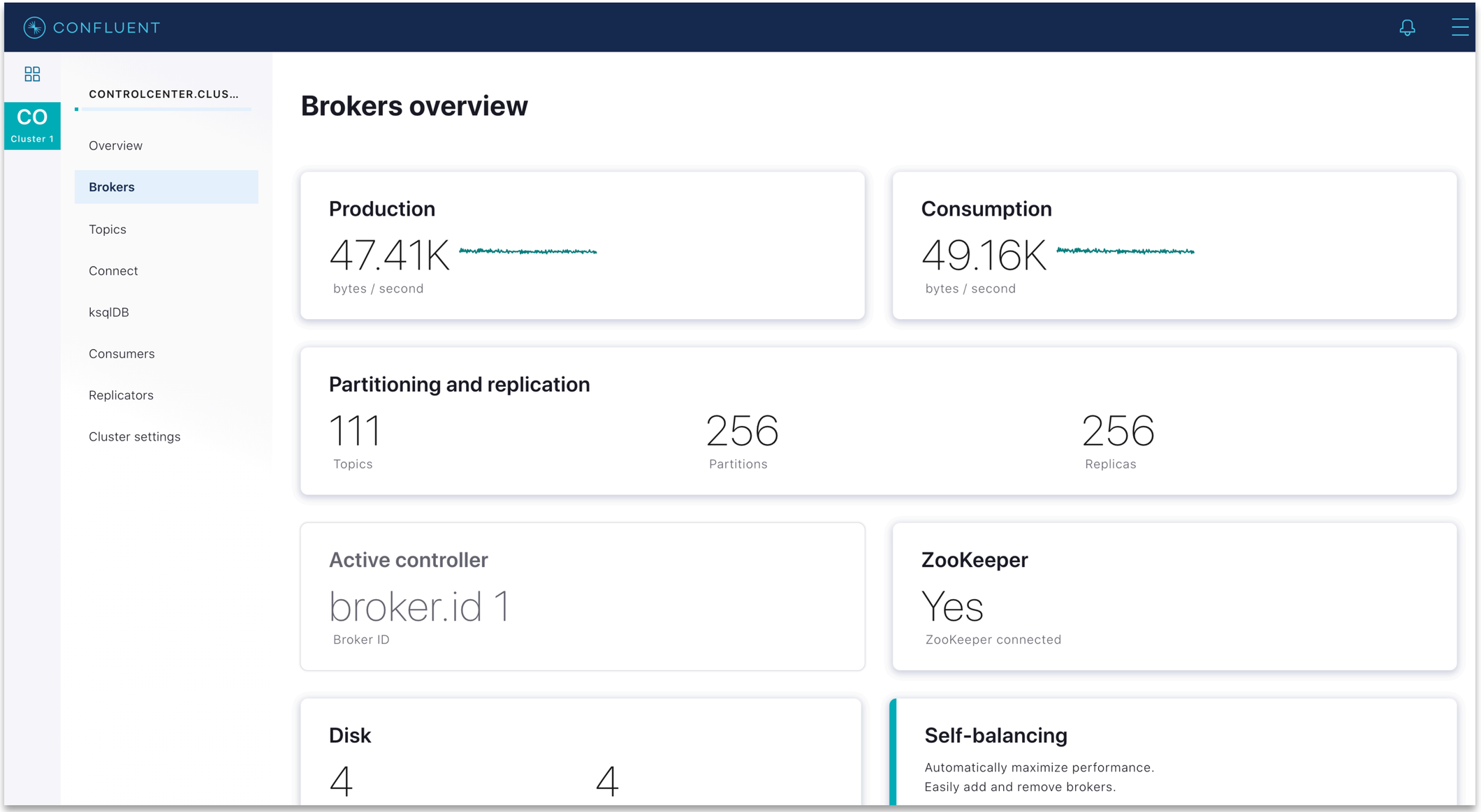
```
curl -X POST -H 'Content-Type: application/json'
     -d '{"chat_id": "-364377679", "text": "This is a test from curl"}'
     https://api.telegram.org/botxxxxx/sendMessage
```

```
{
  "connector.class": "io.confluent.connect.http.HttpSinkConnector",
  "request.method": "post",
  "http.api.url": "https://api.telegram.org/[…]/sendMessage",
  "headers": "Content-Type: application/json",
  "topics": "TRAINS_DELAYED_ALERT_TG",
  "tasks.max": "1",
  "batch.prefix": "{\"chat_id\":\"-364377679\",\"parse_mode\": \"markdown\",",
  "batch.suffix": "}",
  "batch.max.size": "1",
  "regex.patterns":".*\\\{MESSAGE=(.*)\\\}.*",
  "regex.replacements": "\"text\":\"$1\"",
  "regex.separator": "~",
  "key.converter": "org.apache.kafka.connect.storage.StringConverter"
}
```

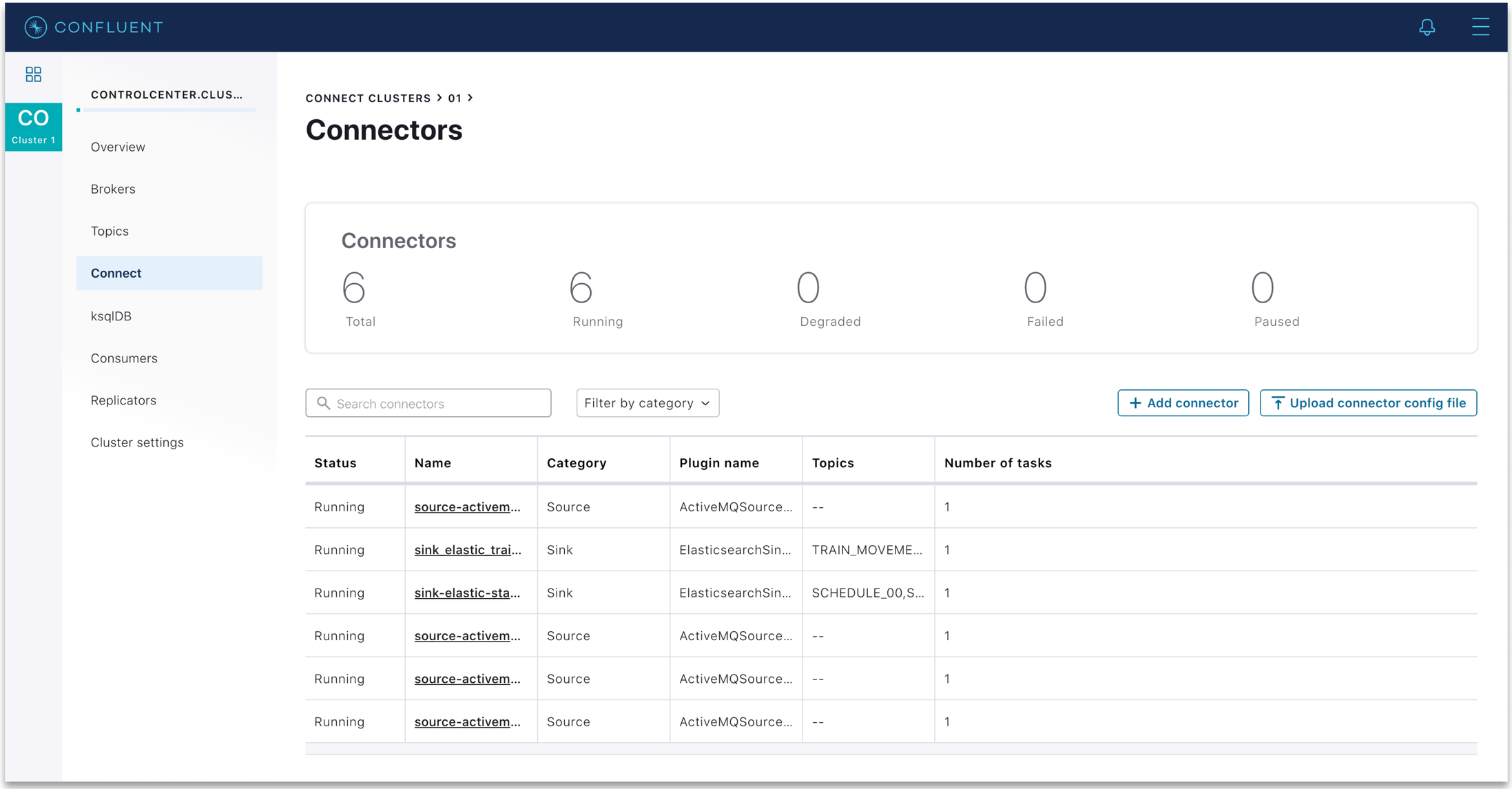


Running it & monitoring & maintenance

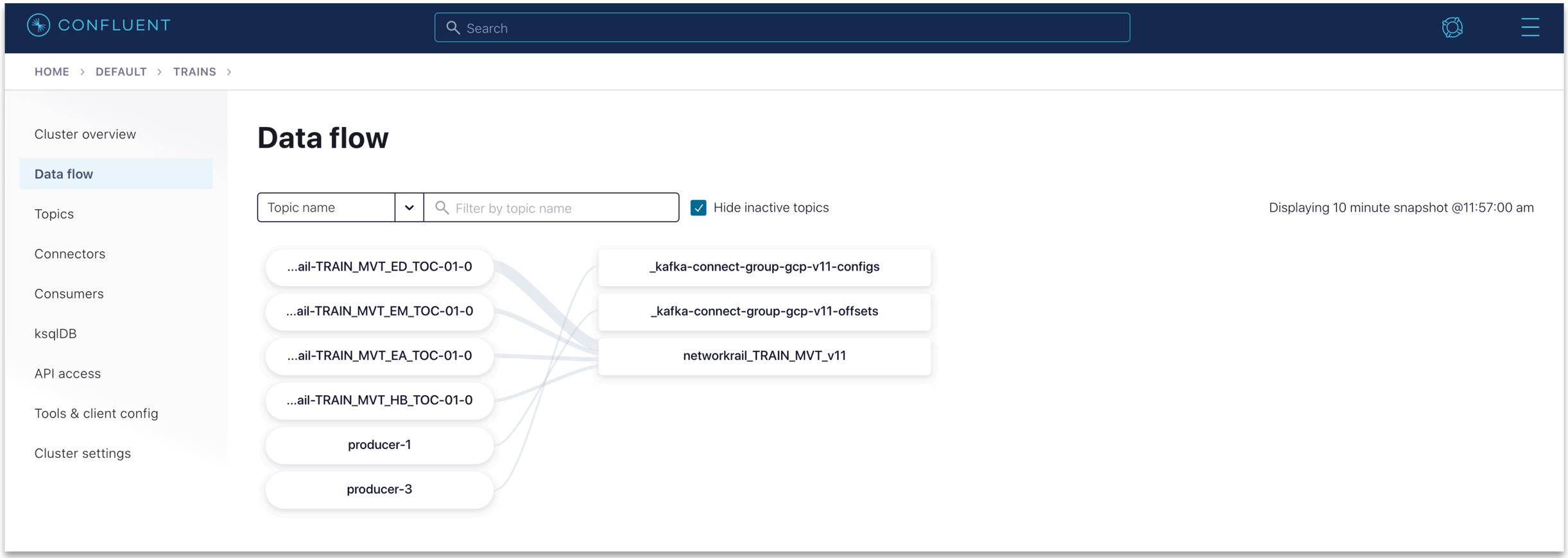
System health & Throughput



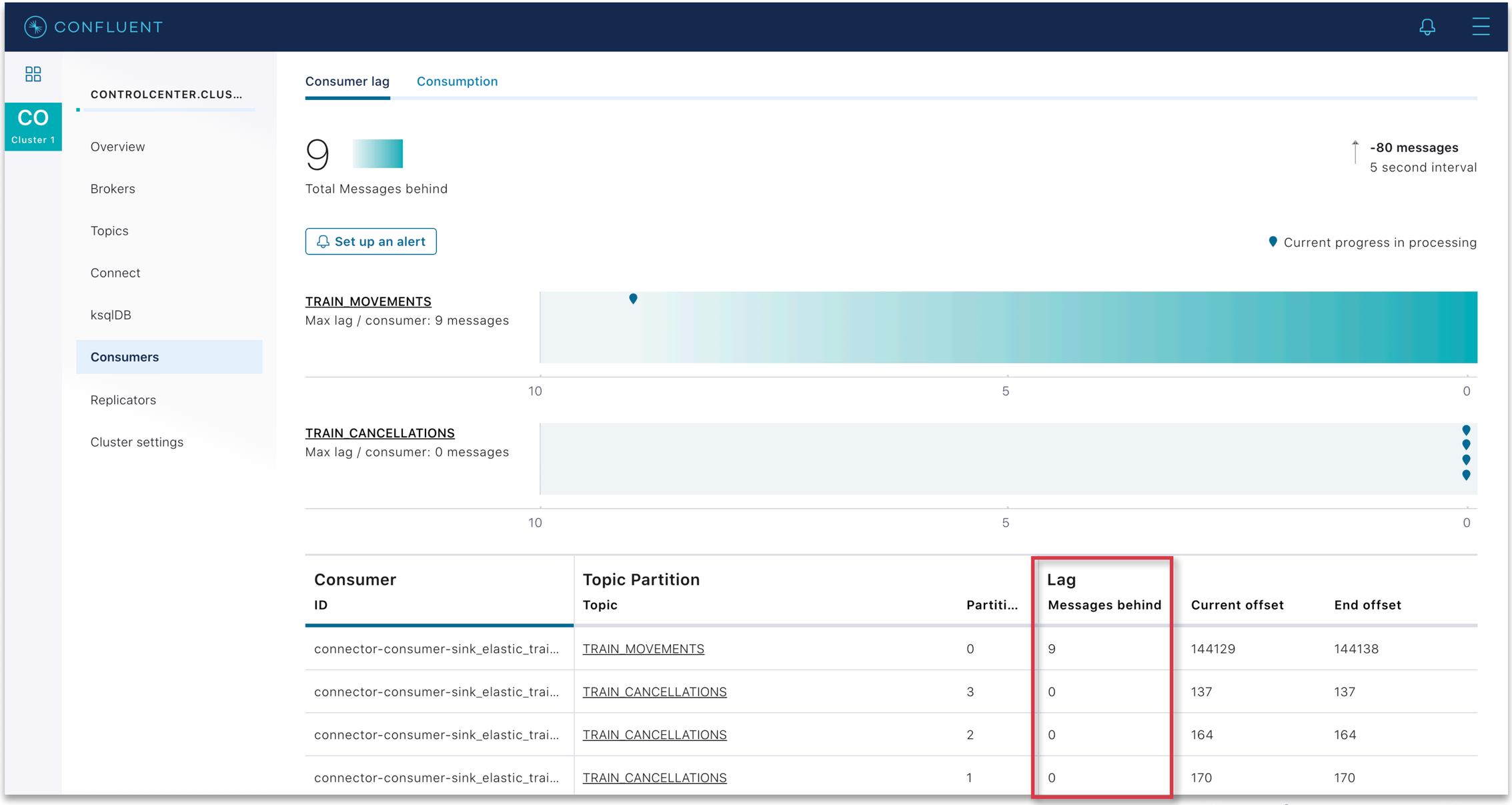
Configuring and monitoring Kafka Connect



Data Flow


CONFLUENT
Search
HOME
DEFAULT
TRAINS
Cluster overview
Data flow
Topics
Connectors
Consumers
ksqlDB
API access
Tools & client config
Cluster settings
Data flow
Topic name
Filter by topic name
Hide inactive topics
Displaying 10 minute snapshot @11:57:00 am
...ail-TRAIN_MVT_ED_TOC-01-0
...ail-TRAIN_MVT_EM_TOC-01-0
...ail-TRAIN_MVT_EA_TOC-01-0
...ail-TRAIN_MVT_HB_TOC-01-0
producer-1
producer-3
_kafka-connect-group-gcp-v11-configs
_kafka-connect-group-gcp-v11-offsets
networkrail_TRAIN_MVT_v11

Consumer lag



Restart failing connectors

```
rmoff@proxmox01 > crontab -l
*/5 * * * * /home/rmoff/restart_failed_connector_tasks.sh


rmoff@proxmox01 > cat /home/rmoff/restart_failed_connector_tasks.sh
#!/usr/bin/env bash
# @rmoff / June 6, 2019

# Restart any connector tasks that are FAILED
curl -s "http://localhost:8083/connectors" | \
  jq '.[]' | \
  xargs -I{connector_name} curl -s "http://localhost:8083/connectors/"{connector_name}"/status" | \
  jq -c -M '[select(.tasks[].state=="FAILED") | .name,"§±§",.tasks[].id]' | \
  grep -v "\[\]"| \
  sed -e 's/^\[\"//g'| sed -e 's/\",\"§±§\",/\/tasks\//g'|sed -e 's/\]$//g'| \
  xargs -I{connector_and_task} curl -X POST "http://localhost:8083/connectors/"{connector_and_task}"/
restart"
```

Is everything running?

http://rmoff.dev/kafka-trains-code-01

```
Every 2.0s: ./list_indices_stats.sh

Connectors
----------
sink-elastic-train_cancellations_02-v01                     |  RUNNING  |  RUNNING
sink-elastic-train_movements_01-v01                         |  RUNNING  |  RUNNING
sink-elastic-train_movements_activations_schedule_00-v01    |  RUNNING  |  RUNNING
sink-jdbc-TRAIN_MOVEMENTS_ACTIVATIONS_SCHEDULE_00           |  RUNNING  |  RUNNING
sink-s3-tiploc-v00                                          |  RUNNING  |  RUNNING
sink-s3-train-movements-v00                                 |  RUNNING  |  RUNNING

Indices and doc count
---------------------
train_movements_activations_schedule_00 2710181
train_movements_01                      2712204
train_cancellations_02                     9383

Indices and timestamp of latest doc
-----------------------------------
2019-06-27 09:00:25             train_movements_activations_schedule_00
2019-06-27 09:00:25             train_movements_01
2019-06-27 08:53:55             train_cancellations_02
```

check_latest_timestamp.sh

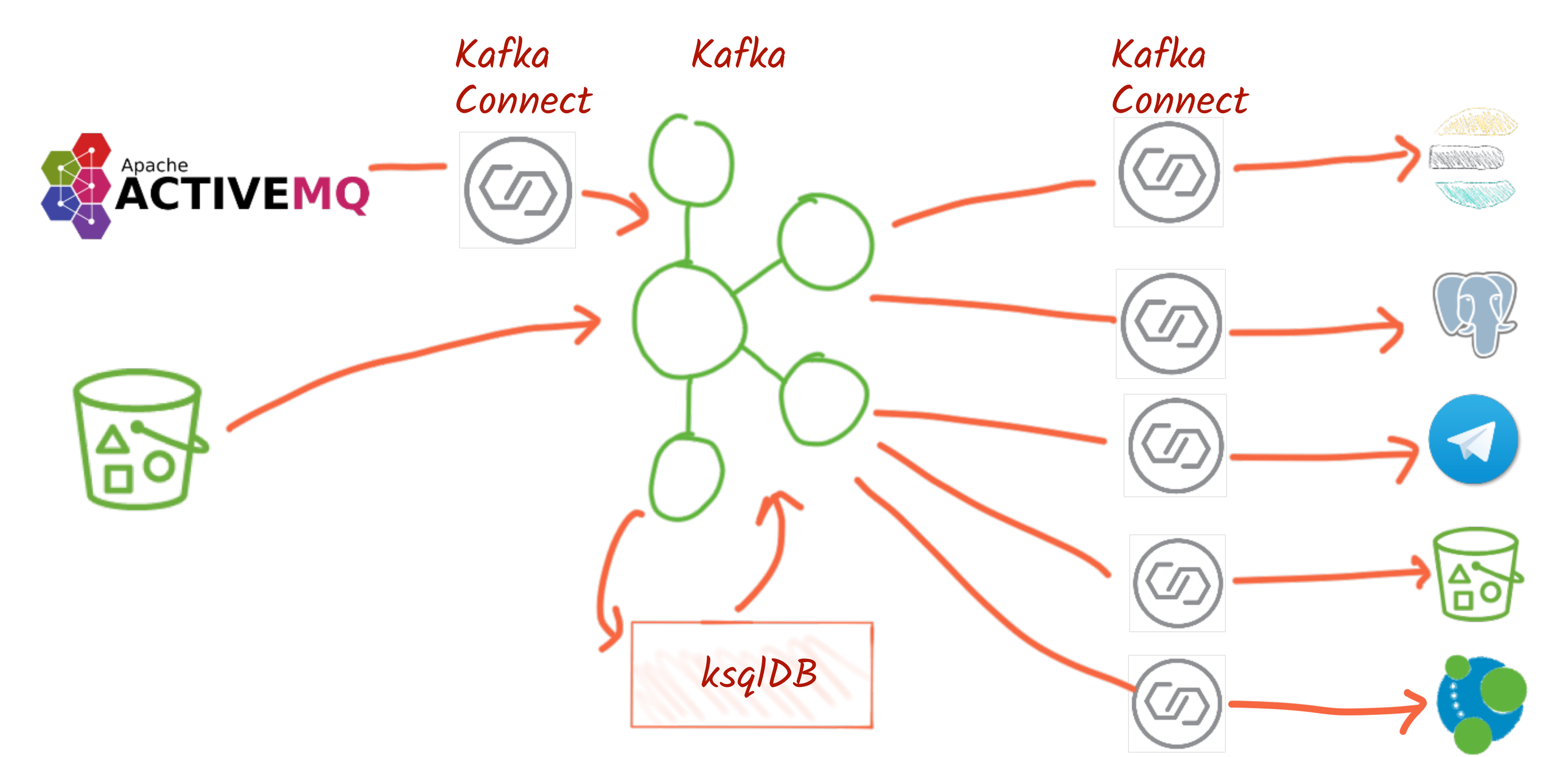
Start at latest message

Just read one message

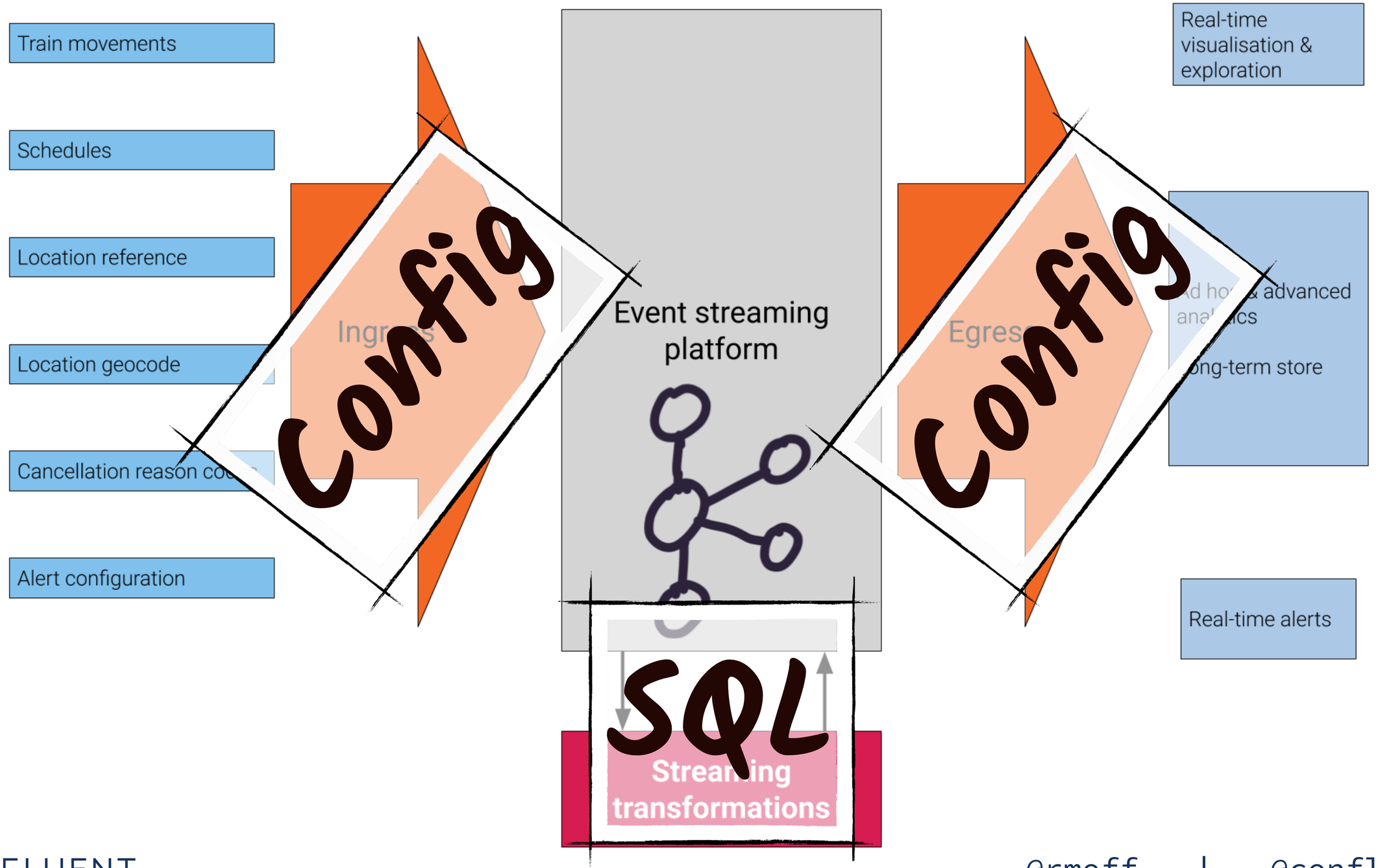
```
kafkacat -b localhost:9092 -t networkrail_TRAIN_MVT_X -o-1 -c1 -C | \
jq '.header.msg_queue_timestamp' | \
sed -e 's/"//g' | \
sed -e 's/000$//g' | \
xargs -Ifoo date --date=@foo
```

Convert from epoch to human-readable timestamp format

```
$ ./check_latest_timestamp.sh
Mon 25 Jan 2021 13:39:40 GMT
```



✅ Stream raw data ✅ Stream enriched data ✅ Historic data & data replay


Train movements
Schedules
Location reference
Location geocode
Cancellation reason co
Alert configuration
Config
Ingress
Event streaming platform
SQL
Streaming transformations
Egress
Config
Real-time visualisation & exploration
advanced
ng-term store
Real-time alerts

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https://rmoff.dev/ccloud

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Fully Managed Kafka as a Service

* T&C: https://www.confluent.io/confluent-cloud-promo-disclaimer

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developer.confluent.io

#EOF